

MS/TP Communications Bus Technical Bulletin

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Refer to the [QuickLIT website](#) for the most up-to-date version of this document.

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Document Introduction

The BACnet® protocol Master-Slave/Token-Passing (MS/TP) communications bus is a local network that connects supervisory controllers and field controllers to field point interfaces.

This document describes the specifications, device limits, and rules of the MS/TP communications bus, as well as how to wire and terminate devices, and troubleshoot device communication on the MS/TP bus. The remote MS/TP field bus is also described. With the addition of a BACnet IP to BACnet MS/TP Router, the Remote Field Bus allows connection to remote field controllers over IP.

This document is intended for the user who needs to know the rules, requirements, limits, specifications, and configuration of the MS/TP bus to design, wire, or troubleshoot an MS/TP application.

Related Documentation

[Table 1](#) lists the related documentation that describes controllers and systems related to the MS/TP communications bus.

Table 1: Related Documentation

For Information On	See Document
Metasys® System Limitations and Overview	<i>Metasys® System Configuration Guide (LIT-12011832)</i>
Installation and Specifications of the NAE55	<i>NAE55/NIE55 Installation Instructions (Part No. 24-10051-43)</i>
Installation and Specifications of the NAE45 or NAE35	<i>NAE35/NAE45 Installation Instructions (Part No. 24-10050-6)</i>
Installation and Specifications of the NCE25	<i>NCE25 Installation Instructions (Part No. 24-10143-63)</i>
Specifications of the Metasys® System Field Controllers	<i>Metasys® System Field Equipment Controllers and Related Products Product Bulletin (LIT-12011042)</i>
Installation and Specifications of the FAC Series Controllers	<i>FAC2611 Advanced Application Field Equipment Controller Installation Instructions (Part No. 24-10143-187)</i>
	<i>FAC2612-1 Advanced Application Field Equipment Controller Installation Instructions (Part No. 24-10143-195)</i>
	<i>FAC2612-2 Advanced Application Field Equipment Controller Installation Instructions (Part No. 24-10143-233)</i>
	<i>FAC3611 Advanced Application Field Equipment Controller Installation Instructions (Part No. 24-10143-470)</i>
Installation and Specifications of the FEC16 or FEC26	<i>FEC16 Field Equipment Controller Installation Instructions (Part No. 24-10143-136)</i>
	<i>FEC26 Field Equipment Controller Installation Instructions (Part No. 24-10143-144)</i>
Installation and Specifications of the IOM Series Controllers	<i>IOM2721 Input/Output Module Installation Instructions (Part No. 24-10144-149)</i>
	<i>IOM3721 Input/Output Module Installation Instructions (Part No. 24-10144-130)</i>
	<i>IOM3731-0A Input/Output Module Installation Instructions (Part No. 24-10144-165)</i>
Installation and Specifications of the IOM17, IOM27, IOM37, or IOM47	<i>IOM17 and IOM27 Input/Output Module Installation Instructions (Part No. 24-10144-76)</i>
	<i>IOM37 Input/Output Modules Installation Instructions (Part No. 24-10144-84)</i>
	<i>IOM47 Input/Output Module Installation Instructions (Part No. 24-10144-92)</i>

Table 1: Related Documentation

For Information On	See Document
Installation and Specifications of the VMA1610, VMA1620, VMA1615, VMA1630, VMA1617, and VMA1632	<i>VMA1610 and VMA1620 Variable Air Volume Controllers Installation Instructions (Part No. 24-10143-20)</i>
	<i>VMA1615 and VMA1630 VAV Controllers Installation Instructions (Part No. 24-10143-217)</i>
	<i>VMA1832 VAV Controller Installation Instructions (Part No. 24-10143-373)</i>
Specifications of the Wireless Commissioning Converter and Setting up a Bluetooth® Wireless Technology Adapter	<i>Wireless Commissioning Converter Installation Instructions (Part No. 24-10108-2)</i>
	<i>Metasys CCT Bluetooth Technology Communication Commissioning Guide (LIT-12011038)</i>
Integrating BACnet® MS/TP and BACnet IP Devices into the Metasys System Network	<i>BACnet® Controller Integration with NAE/NCE Technical Bulletin (LIT-1201531)</i>
Installation of and Specifications for the MS-BACEOL-0 End-of-Line Terminator Module	<i>MS-BACEOL-0 RS485 End-of-Line Terminator Installation Instructions (Part No. 24-10264-4)</i>
Wiring and Configuration for the Loytec BACnet Router	<i>LIP-ME201 User Manual. Refer to http://www.loytec.com</i>
Designing, Installing, Commissioning, Operating, and Troubleshooting a ZFR1800 Series System on a Metasys Network	<i>ZFR1800 Series Wireless Field Bus System Technical Bulletin (LIT-12011295)</i>
Locating, Mounting, and Wiring ZFR1810 Coordinators and ZFR1811 Routers	<i>ZFR1810 Wireless Field Bus Coordinator Installation Instructions (Part No. 24-10325-2)</i>
Locating, Mounting, and Wiring ZFR1811 Routers	<i>ZFR1811 Wireless Field Bus Router Installation Instructions (Part No. 24-10325-10)</i>
Locating and Installing WRZ-TTx Series Sensors	<i>WRZ-TTx Series Wireless Room Temperature Sensors Installation Instructions (Part No. 24-10332-2)</i>
Applications, Features, and Benefits of the ZFR1800 Series Wireless Field Bus System	<i>ZFR1800 Series Wireless Field Bus System Product Bulletin (LIT-12011336)</i>
Estimating Quantity, Locating, and Testing ZFR1800, Coordinators, ZFR1811 Routers, and WRZ-TTx Series Sensors	<i>Wireless Metasys System Location Guide (LIT-12011294)¹</i>
Controller Configuration Tool (CCT) Software	<i>Controller Tool Help (LIT-12011147)²</i>

1 This document is only available on the Johnson Controls® Portal intranet site.

2 This LIT number represents a printer-friendly version of the Help.

MS/TP Bus Overview

The MS/TP bus is based on BACnet® standard protocol SSPC-135, Clause 9.

The BACnet MS/TP protocol is a peer-to-peer, multiple master protocol based on token passing. Only master devices can receive the token, and only the device holding the token is allowed to originate a message on the bus. The token is passed from master device to master device using a small message. The token is passed in consecutive order starting with the lowest address. Slave devices on the bus only communicate on the bus when responding to a data request from a master device.

Important: Do not connect MS/TP devices and N2 devices to the same bus. MS/TP communications buses follow different protocol and wiring rules from N2 communications buses, and MS/TP devices and N2 devices are not compatible on the same bus.

An MS/TP bus ([Figure 1](#)) is used for two types of buses: a Field Controller bus (FC) and a Sensor Actuator (SA) bus. The MS/TP bus can also be extended remotely over the IP network with the addition of a BACnet IP to MS/TP router ([Figure 2](#)).

The FC bus, SA bus, and Remote Field Bus are networks of daisy-chained devices. Each bus has only one bus supervisor, depending on which controllers are connected. On a local FC bus, the bus supervisor is the supervisory engine. On the local SA bus, the bus supervisor is a field controller. On the Remote Field Bus, the bus supervisor is the BACnet IP to BACnet MS/TP Router (hereafter called the BACnet Router), which works with the supervisory engine when a Remote Field Bus is installed.

Note: When you install a BACnet Router for adding a Remote Field Bus to the job site, you need a site-level, unique MS/TP network number and device object ID (if it contains a device object) for the BACnet Router. In addition, it is critical that you determine if a BACnet Broadcast Management Device (BBMD) is required for the BACnet Router. If you configure the BACnet Router as a BBMD, assign a static IP address to both the router and the NxM or ODS where you are configuring the MS/TP bus. For an existing installation, contact the BAS Manager, Building Manager, or IT department for information on available network numbers, device object IDs, and existing BBMDs for crossing IP subnets. Information on configuring a BBMD in a BACnet Router (if it supports them internally) is available from the router vendor.

The bus supervisor communicates with devices on the supervised bus and with devices on the next (higher level) bus on the network. The bus supervisor typically starts the communication on the FC bus, remote FC bus, or SA bus. If an SA bus, FC bus, or Remote Field Bus does not have a bus supervisor, the master device with the lowest device address value on the bus and a specific baud rate selected starts the communication.

The ZFR1800 Series Wireless Field Bus System enables wireless communication on an MS/TP bus, allowing you to create wireless connections between Advanced Application Field Equipment Controllers (FACs), Field Equipment Controllers (FECs), or VAV Modular Assemblies (VMAs), Input Output Modules (IOMs), and Network Automation Engines (NAEs) or Network Control Engines (NCEs).

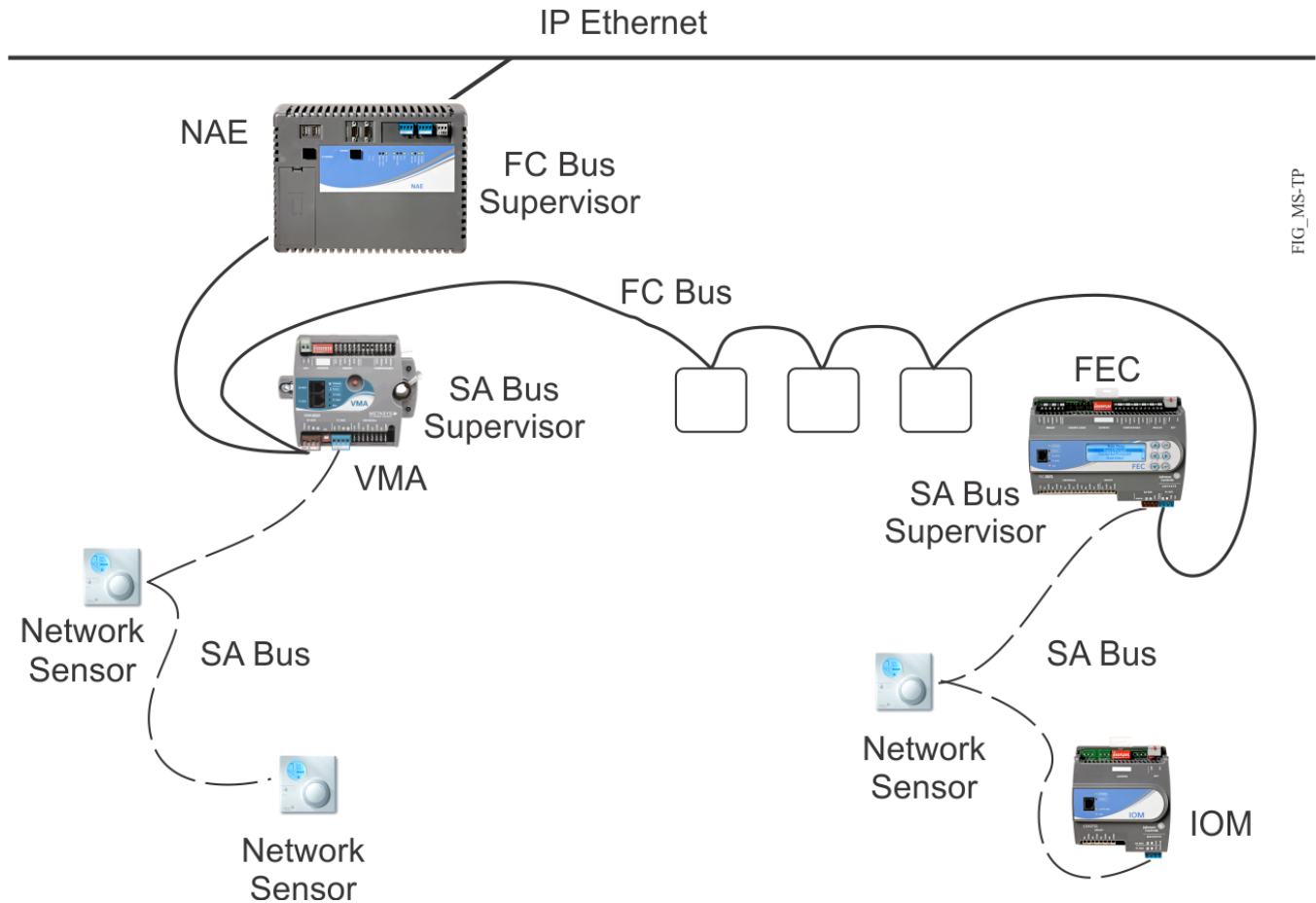
See [Enabling Field Controllers for Wireless Operation](#) and [Related Documentation](#) for detailed information about the ZFR1800 Series Wireless Field Bus System.

Note: The ZFR1800 Series Wireless Field Bus System **is not** supported on the Remote Field Bus.

FC Bus

An FC bus connects a Metasys® system NAE or NCE to FACs, FECs, VMA16s, IOMs, and TEC26xx Series thermostats. Third-party BACnet MS/TP devices can also be connected to the FC bus.

Figure 1: Example of an MS/TP Communications Bus



On an FC bus, the NAE or NCE is the bus supervisor. An FC bus supports up to three bus segments that are connected with network repeaters ([Figure 9](#)). See [Local FC Bus Rules and Specifications](#) for more information.

SA Bus

The SA bus connects NCEs, FACs, FECs, and VMA16s (field controllers) to end point devices such as IOMs, network thermostats, network sensors, and Johnson Controls Variable Speed Drives (VSDs).

On an SA bus, an NCE, FAC, FEC, or VMA16 is the bus supervisor. The SA bus is a private MS/TP bus that only supports those devices that can be defined using the CCT programming tool. The bus does not support bus segments ([Figure 11](#)). See [SA Bus Rules and Specifications](#) for more information.

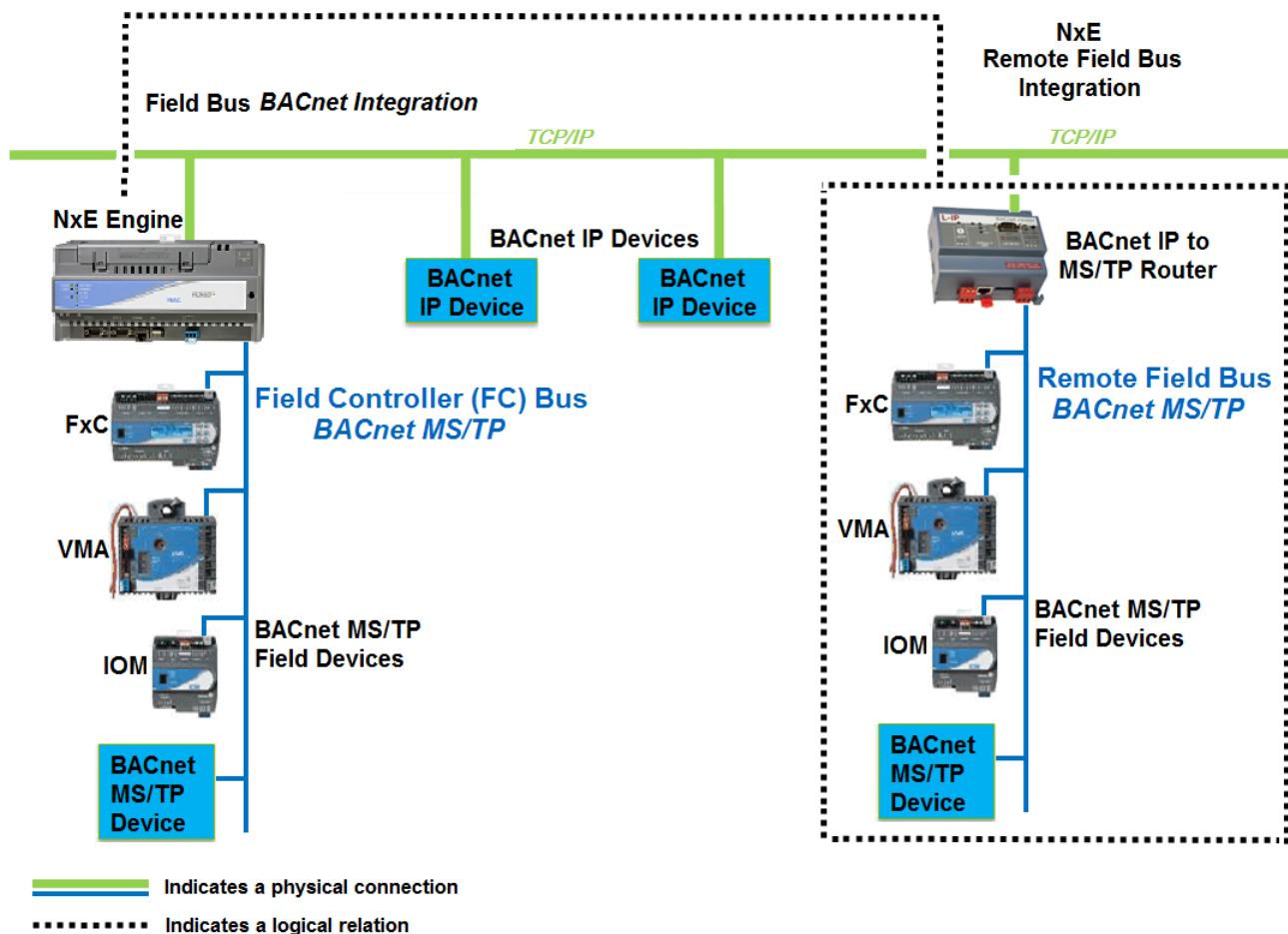
Remote Field Bus

The Remote Field Bus uses a BACnet Router to connect remote BACnet MS/TP devices such as FECs and VMA16s to the Metasys network. These devices include FACs, FECs, VMA16s, IOMs, TEC26xx Series thermostats, and other BACnet MS/TP field devices. Although several routers from different manufacturers are available, the recommended device is the LIP-ME201™ BACnet Router from Loytec Electronics GmbH. **Do not** use any USB-powered MS/TP to IP converter, including the Johnson Controls® BACnet to MS/TP Router (TL-BRTRP-0).

Use a Remote Field Bus for applications where routing an RS-485 network directly to an NxE supervisory engine is not practical because of distance, cost, or poor accessibility. In many cases, an IP network connection is available at both the NxE supervisory engine and at some point near the BACnet MS/TP devices. By leveraging the Metasys Remote Field Bus capability with installing the BACnet Router near the BACnet MS/TP devices, you can reduce system cost. Also, when you choose MS/TP device integration with a router rather than BACnet Integration, access to proprietary attributes, message types, and objects from Metasys field controllers is available. This functionality provides you with more information and more capability than the standard BACnet attributes, services, and object types. For example, at the Site Management Portal you can view proprietary attributes such as communication statistics from mapped FEC Family devices. Also, remote MS/TP device integration supports the CCT Pass Through option for downloading devices directly connected to the Remote Field Bus (but not to devices connected to the sensor bus).

Figure 2 shows an example of a Metasys network with a Remote Field Bus.

Figure 2: Example of a Remote Field Bus

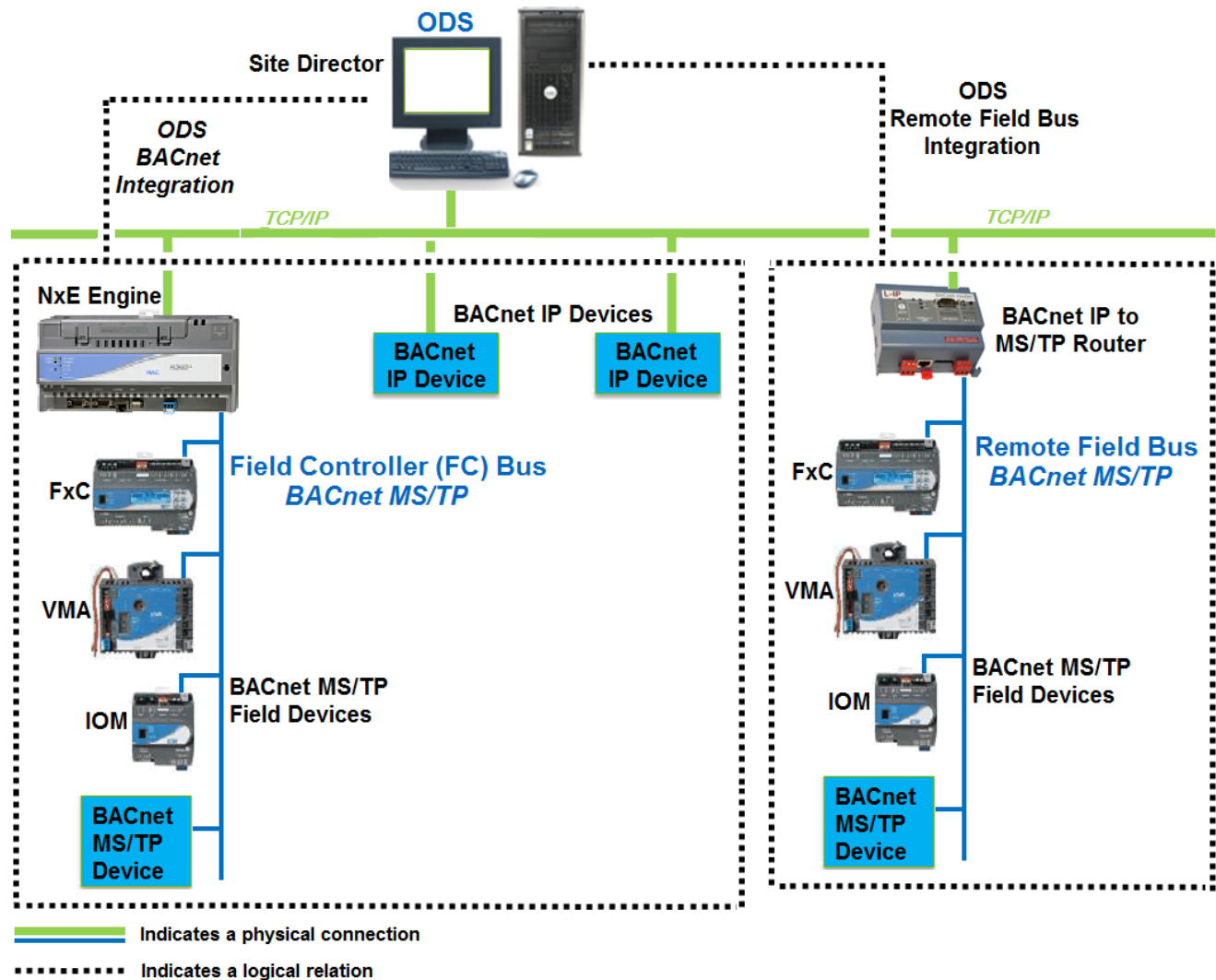


All devices in the BACnet Integration are treated as BACnet devices, including Johnson Controls devices, if they are discovered and mapped online with the Discover All As General BACnet Device attribute set to True.

The Remote Field Bus is defined at a Metasys NxE supervisory engine or Open Data Server (ODS) Workstation ([Figure 3](#)) through field bus integration, similar to how a local MS/TP field bus is added. The Remote Field Bus appears on the All Items Navigation tree in the Site Management Portal UI. You can also provide a custom name to clearly identify the type of integration.

Note: To ensure acceptable system performance, make sure that you map all devices and objects that originate from a Remote Field Bus to a single supervisory engine, for example, if you have two NAEs (NAE-1 and NAE-2), each with a separate Remote Field Bus. Device 1 is defined under NAE-1, and Device 2 is defined under NAE-2. In this arrangement, make sure you do not map Device 1 to NAE-2 or map Device 2 to NAE-1. If you mix remote field device mapping between supervisory engines, the Metasys system may start very slowly, and devices may have difficulty staying online.

Figure 3: Example of a Remote Field Bus with ODS



Applications for the Remote Field Bus include:

- Any intra-building, inter-building, or remote location that has IP network connections readily available
- Locations where it is cost prohibitive or difficult to run MS/TP wiring between devices and the NxEs, due to distance, cost, accessibility, or customer factors
- Locations where field controllers are segregated from the NxEs
- Intra-building applications that connect segregated locations within a building (for example, connecting penthouses to mechanical rooms)

- Remote buildings where an MS/TP bus is not already available, but an Ethernet BACnet/IP network is (for example, university or hospital campuses)
- Sites with a reliable network between buildings that do not need to have a separate NAE for the building (for example, school districts)

Note: The ZFR1800 Series Wireless Field Bus System **is not** supported on the Remote Field Bus.

For details on how to add a Remote Field bus, refer to the *MS/TP Field Bus Integration Object* section in Metasys SMP Help (LIT-1201793). For details on how to add a Remote Field Bus to a Metasys supervisory engine with an ODS, refer to the *ODS Commissioning Guide* (LIT-12011944).

Additional background on the Remote Field Bus is covered in the following sections:

- [BACnet Router Configuration](#)
- [Supervisory Engine Configuration for Adding Remote Field Bus](#)
- [BACnet Router Wiring](#)
- [Remote Field Bus Restrictions](#)
- [Remote Field Bus Status and Statistics Attributes](#)
- [Remote Field Bus Status Commands](#)

BACnet Router Configuration

Configuration of the BACnet Router varies by vendor and model of the device, but several important configuration settings are required for all routers. [Table 2](#) lists those settings and [Figure 4](#) provides an example. For more details on BACnet Router parameters, refer to the documentation provided with your router.

Note: When you install a BACnet Router for adding a Remote Field Bus to the job site, you need a site-level, unique MS/TP network number and device object ID (if it contains a device object) for the BACnet Router. In addition, it is critical that you determine if a BACnet Broadcast Management Device (BBMD) is required for the BACnet Router. If you configure the BACnet Router as a BBMD, assign a static IP address to both the router and the NxE or ODS where you are configuring the MS/TP bus. For an existing installation, contact the BAS Manager, Building Manager, or IT department for information on available network numbers, device object IDs, and existing BBMDs for crossing IP subnets. Information on configuring a BBMD in a BACnet Router (if it supports them internally) is available from the router vendor.

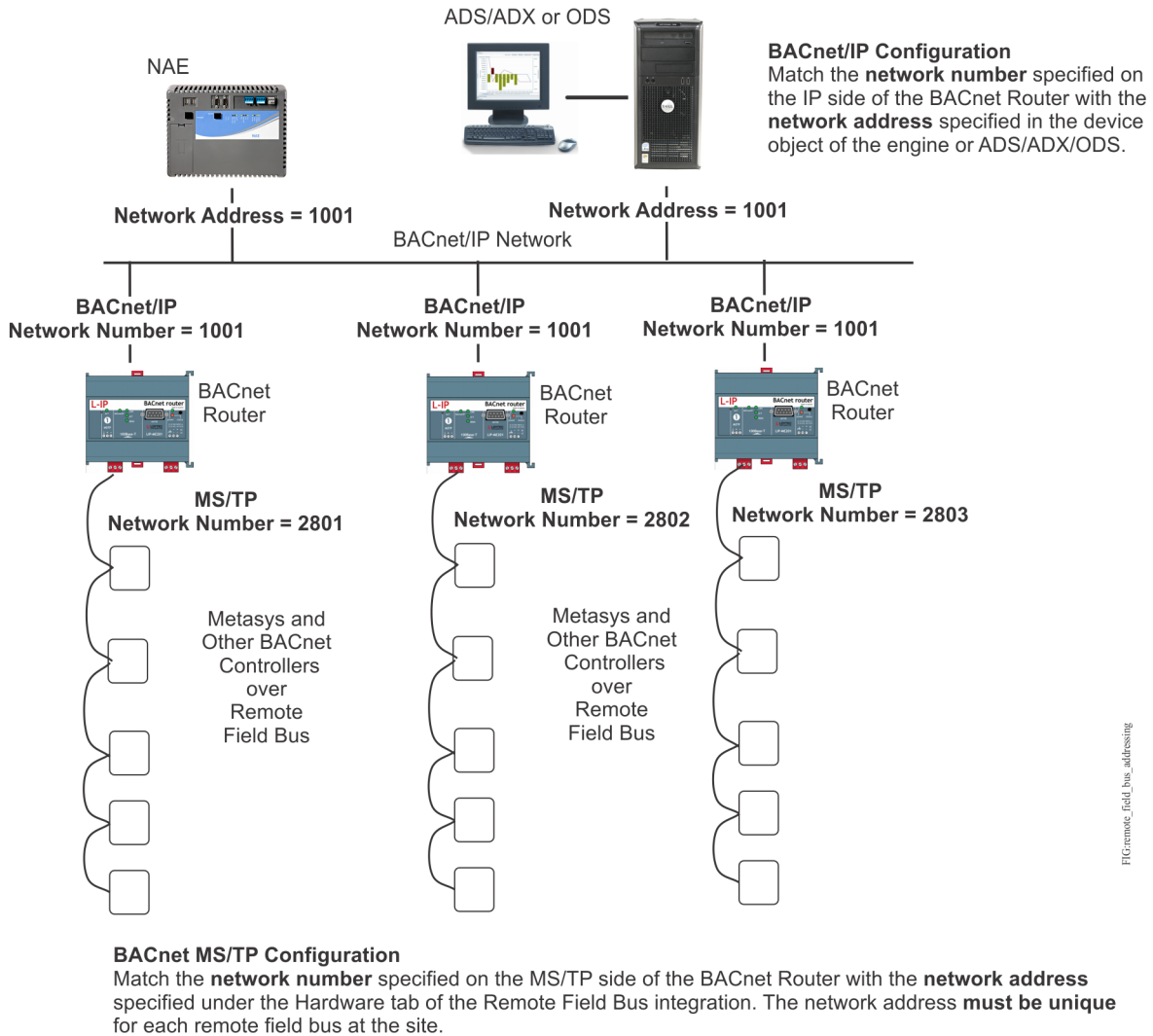
Table 2: BACnet Router Attributes

BACnet Router Attribute Name	Description	User Action or Recommended Setting
Network Number (for Ethernet BACnet/IP)	A unique identifier defined for the BACnet IP network connection on the BACnet Router. The supervisory engine uses this number to locate the device.	Specify the network number assigned for BACnet/IP connections to the BACnet network. Do not use 2000 or 65000 as the network number; these numbers are used for existing embedded networks. Note: In most cases, the IP side of the BACnet Router shares the same Network Number as all of the BACnet IP connections in one BACnet network (example: 1001). Figure 4 shows an example.
Network Number (for BACnet MS/TP, Port 1)	A unique identifier defined for the BACnet MS/TP network connection on the BACnet Router.	Specify the network number for the BACnet Router on the MS/TP side with the network address specified in the Metasys supervisory engine under which the Remote Field Bus is defined. The MS/TP side of each BACnet Router must have a unique Network Number for the site because each remote bus is a separate network (example: 2801, 2802, 2803). Do not use the same network number as any of the NAE MS/TP trunks. Figure 4 shows an example.
Device ID	The Device ID is the instance number for the BACnet Router. This number must be unique across the building networks for all device instances.	Specify a unique number. Note: As you add routers, be sure to replace the router's default device ID with a unique value for your site. The router's device ID must be different from the device ID of all other BACnet devices at the site.
Device Name	A name to identify the BACnet Router. This name must be unique across the building network.	Specify a unique name.
BACnet/IP Broadcast Management Device (BBMD)	The IP network subnets used by both the BACnet Router and the supervisory engine normally require that you define BBMDs on each subnet if those IP subnets are different. Each IP subnet generally requires exactly one defined BBMD. Many routers include BBMD capability in order to simplify this requirement.	Enable and configure the router BBMDs with an appropriate broadcast distribution table.

Table 2: BACnet Router Attributes

BACnet Router Attribute Name	Description	User Action or Recommended Setting
MS/TP MAC Address	The MS/TP MAC address of the BACnet Router you select must not conflict with any other MS/TP device on the same wire. Address zero (0) is generally recommended. For other field devices connected to the same RS-485 MS/TP bus, use sequential addressing following the Metasys MS/TP bus addressing recommendations and reserved addresses. No single MS/TP MAC address can be used by more than one device on the same MS/TP bus regardless of the type of device.	default=0
Baud Rate	The RS-485 connection on the BACnet Router requires a specified baud rate in order to initiate communication with field devices that may use auto-baud rate configuration.	38400
MS/TP Max Master	The highest master MS/TP node number used on the bus.	127
MS/TP Max Info Frames	The Max Info Frames setting on the BACnet Router you specify should be high enough to allow the transmission of at least as many MS/TP frame packets as there are available MS/TP frame buffers in the router.	80 to 100 (all devices are Johnson Controls field devices) or 20 (some or all devices are third-party field devices)
Max APDU Length	The maximum size of a BACnet APDU (Application Layer Protocol Data Unit) accepted by the device. For most BACnet Routers, this is a read-only attribute that is fixed to the maximum value defined for BACnet MS/TP.	480 (or use default)
Router Configuration Password (if available)	A password that you must enter to access the BACnet Router configuration settings.	To protect from intruders, change the default password.
IP settings	The BACnet Router requires common IP communication configuration settings for the UDP port (default 47808), IP network, and IP subnet mask.	Set these appropriately for the site and the router.

Figure 4: Setting Network Address or Network Number



FIGremote_field_bus_addressing

Supervisory Engine Configuration for Adding Remote Field Bus

You define the Remote Field Bus at a Metasys supervisory engine much like you define a local field bus. Important settings include Trunk Number and Network Address.

Trunk Number

On a supervisory engine, trunk numbers 1 and 2 are reserved for the local field bus integration. Trunk numbers 3 to 20 are reserved for Remote Field Bus integrations. The quantity of field buses supported on any particular device varies according to the specific device in use. Generally, the number of supported trunks is **less than** the maximum trunk number allowed ([Table 3](#)). For example, an ODS supports 16 field buses maximum, not 20 field buses as the trunk number range would suggest. If the specific device does not support a local field bus, such as an NxE85, start with trunk 3, as trunk numbers 1 and 2 are not supported.

Network Address

The network address you specify for a Remote Field Bus integration must match the BACnet Router MS/TP-side network number you specify. The network address must be unique at the site. Keep in mind that each MS/TP trunk on each NxE has a network number that needs to be considered when determining a unique ID. This address is used to locate and establish communication between the Remote Field Bus and the router. A defined Remote Field Bus can only work with one router. If you need to change the network address of a Remote Field Bus after it has been configured, you must restart the Metasys supervisory engine to complete the re-configuration.

Number Of Field Buses Allowed

The total number of local and remote field buses allowed depends on the type of controller as outlined in [Table 3](#). For example, an NIE55 can have up to eight field buses, but an NCE25 or NIE29 can only support one local field bus and no remote field bus.

Table 3: Maximum Number of Field Buses per Controller

Controller	Maximum Number of Field Buses (local and remote)
NAE55 / NIE59	8
NAE35 / NAE45 / NIE39 / NIE49	4
NCE25 / NIE29	1 (local field bus only; Remote Field Bus not supported)
NAE85 / NIE89	16
ADS / ADX / ODS	16

Note: The Remote Field Bus supports up to 32 field devices per BACnet Router on a bus with all Johnson Controls devices, or up to 16 field devices on a bus with a mix of Johnson Controls and third-party devices. Limitations are listed in the *Metasys System Configuration Guide (LIT-12011832)*. Also, to take advantage of bus diagnostics, at least one Johnson Controls field device is required on the Remote Field Bus.

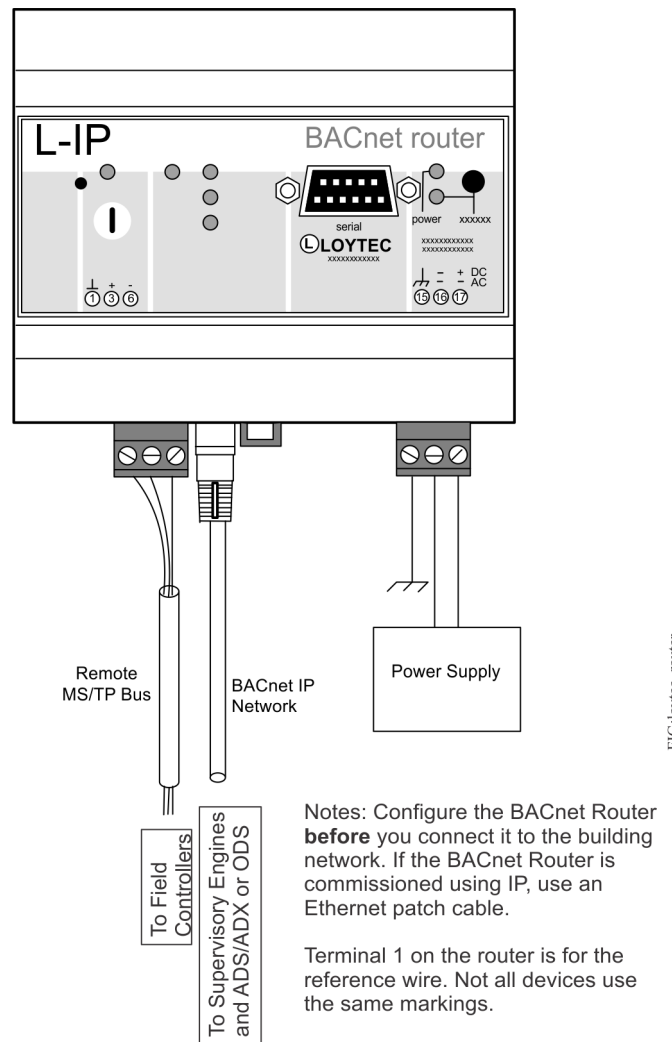
Configuration Attributes Only For Local Field Bus

If the same field bus configuration attribute is specified at both the BACnet Router and the Remote Field Bus, the attribute setting on the BACnet Router prevails. For example, if a Baud Rate of 38400 is specified at the BACnet Router but a Baud Rate of 76800 is specified on the Remote Field Bus, 38400 is used as the Baud Rate on the bus. To be consistent, we recommend that you match the Remote Field Bus attribute values with that of the router, or you can keep the default values at the Metasys supervisory engine. See [BACnet Router Configuration](#) for a partial attribute list.

BACnet Router Wiring

[Figure 5](#) shows how to wire the BACnet Router to the Metasys system. This example features the Loytec Router, Model LIP-ME201™, the recommended device from Loytec Electronics GmbH.

Figure 5: Wiring BACnet Router



Remote Field Bus Restrictions

Compared to the local MS/TP field bus, the Remote Field Bus has several operational restrictions.

Number of Field Controllers on a Remote Field Bus

The number of controllers that can successfully operate on a Remote Field Bus is generally less than that of a local field bus, and is heavily dependent on the capabilities of the router used. Generally, a good quality router can support at least 10 BACnet MS/TP devices, and some can support more. (See [Table 10](#).) If you notice that devices go offline randomly, or you notice a large number of BACnet message retries, you may have exceeded the maximum number of supported devices for the router. You may be able to use a larger number of devices if you mitigate the message traffic that originates from field devices located on the Remote Field Bus.

Maximum Change of Values (COVs)

The total number of COVs per supervisory engine must remain at less than 500 per minute. To determine and tune the number of COVs per minute on a Remote Field Bus, use the FDD tool, but only if you have at least one Johnson Controls field controller on the bus. The FDD tool helps you find chatty devices and helps decrease the COV rate by updating the COV increments.

Field Controller Main Code Release

For Remote Field Bus compatibility, the Main Code for the field controllers you connect to remotely must be at Metasys system Release 5.3 or later. Remote field bus communication is not as robust with controllers that are running older releases of the Metasys system.

CCT Pass Through Loading

Generally, you can upload and download code and applications with CCT Pass Through for devices directly connected to a Remote Field Bus (subject to router message load levels). However, you cannot use CCT Pass Through to download code to an IOM connected to the SA bus of a field controller. In these situations, use a Wireless Commissioning Controller at the remote location.

Device and Point Mapping

When you define a Remote Field Bus, be sure to map all devices and points at the remote controllers through the same Remote Field Bus. For most networks, a detrimental increase in router traffic occurs if multiple integrations use the same router and network number. This is true regardless of where the multiple integrations are defined or if a BACnet Integration is used.

Remote Field Bus Status and Statistics Attributes

With the local field bus, the status and statistics values are obtained directly from the MS/TP communication software, which has direct access to the MS/TP communication frames. However, with the Remote Field Bus, the status and statistics values must be obtained from one of the remote FEC Family BACnet controllers communicating through the BACnet Router. When at least one Metasys MS/TP field controller is mapped to the Remote Field Bus as an FEC Family BACnet device, the system can retrieve and display the status and statistics values from the Remote Field Bus. Be aware that if this field controller goes offline and a different FEC Family field controller is selected to provide remote bus statistics, the values obtained may abruptly change because the values are from a different controller. This is normal operation.

The following Metasys attributes are located under the Diagnostics tab of a Remote Field Bus.

Logging Object Reference

This attribute indicates the remote Metasys MS/TP field controller configured for obtaining MS/TP trunk status and statistics values. The device name appears if available; otherwise, the MAC address on the MS/TP trunk appears. The value is empty for a local field bus, or if no Metasys field controller is available or known. The remote Metasys device is chosen by first looking for an online, mapped FEC Family BACnet device. If none is found, then the Analyze Field Bus command results (if any) are scanned for a possible FEC family device.

Bus Health Index and Bus Performance Index

Trunk health and performance moving average calculations are generally delayed one update time (usually one minute) on a Remote Field Bus due to the delays in reading raw statistics values remotely. As mentioned previously, the numbers reported experience a transient glitch if you change the Metasys BACnet device used to gather statistics.

Port Status

The value of this attribute is **Remote Trunk** for a Remote Field Bus. For an online local field bus, the value of this attribute is **Active**.

Remote Field Bus Status Commands

The Site Management Portal UI offers a few commands that relate to Remote Field Bus operation.

Latch Statistics

The Latch Statistics command is redirected to the FEC Family BACnet Device used for collecting MS/TP trunk statistics.

Clear Statistics

The Clear Statistics command is redirected to the FEC Family BACnet Device used for collecting MS/TP trunk statistics. If the device used for collecting statistics changes after this command is issued, the new device is not cleared unless the command is issued again.

Sync Field Device Time(s)

The Sync Field Device Time(s) command sends a high-priority time synchronization command to all child BACnet Integration devices, based on each device mapper object's Manual Time Sync Type attribute.

If the Manual Time Sync Type is set to:

- **UTC:** UTC time synchronization message is sent.
- **Local:** A local time synchronization message is sent.
- **None:** No message is sent.
- **Auto:** The mapper object's Protocol Services Supported attribute is used to determine which type of time sync is supported, and if:
 - utcTimeSynchronization is set, the code functions as if Time Sync Type is set to UTC.
 - utcTimeSynchronization is not set and timeSynchronization is set, local time is set.
 - neither utcTimeSynchronization nor timeSynchronization is set, an error is returned.

Analyze Field Bus

The Analyze Field Bus option has been modified on a Remote Field Bus to use BACnet services that can pass through routers. (The local field bus operation can use MS/TP test messages, which do not pass through routers.) In addition, the bus can only detect remote devices that answer the wild card device instance value of 4194303. Some commonly used MS/TP devices do not respond to the wild card device instance value and are not detected by this operation. Devices already mapped are always displayed.

Note: Running a bus analysis remotely requires significantly more time to complete than what a local field bus requires, and adds significant message loading to the router while running.

End-of-Line Termination on the MS/TP Bus

Daisy-chained RS485-protocol networks typically require some type of end-of-line (EOL) termination to reduce interference caused by signal reflection that occurs when data transmissions reach the end of a bus segment and bounce back on the segment. The high baud rates on MS/TP bus applications require robust EOL termination and strict adherence to the EOL termination rules. [Figure 6](#) shows an example of the EOL termination settings on an MS/TP bus application.

The EOL termination requirements for the FC bus are different from the SA bus requirements. See [EOL Termination on the Local FC Bus](#) and [EOL Termination on the SA Bus](#) for more information.

Also, third-party MS/TP devices and TEC26xx Series thermostats have different EOL termination requirements from Metasys devices on the FC bus. See [TEC26xx Series Thermostats and Third-Party MS/TP Devices](#) for more information.

Figure 6: EOL Terminations on an MS/TP Bus
IP Ethernet

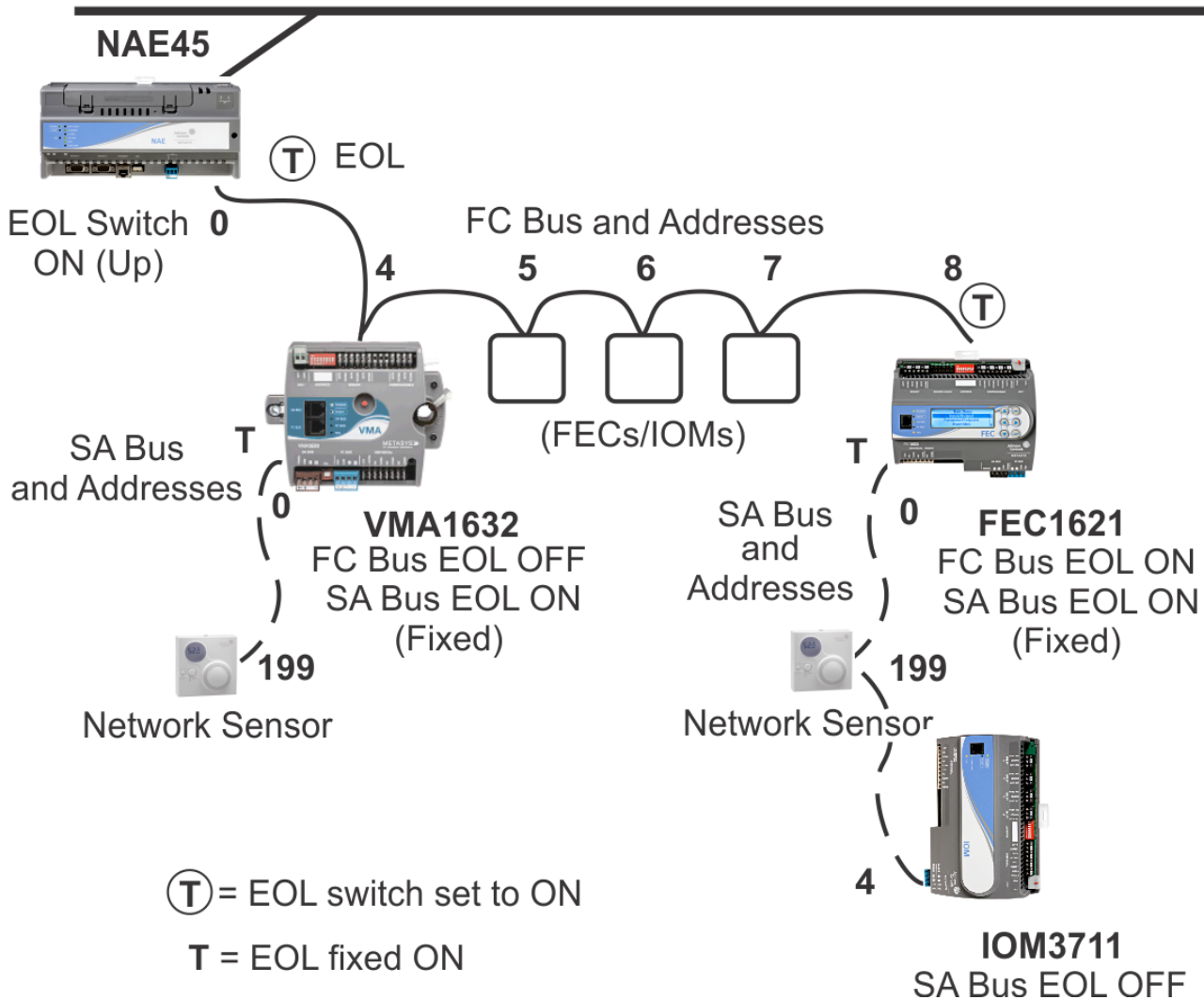


FIG:netwrk_exmpl

Baud Rates on the MS/TP Bus

An MS/TP bus can be configured to communicate at one of four different baud rates. All of the devices on an MS/TP bus must communicate at the same baud rate.

The baud rate setting determines the rate at which devices communicate data over the bus. The baud rate settings available on Metasys MS/TP devices are 9600 bps, 19.2 kbps, 38.4 kbps, 76.8 kbps, and Auto. The baud rate setting for Metasys devices is set in the Metasys software.

Note: The BACnet Standard only requires support for 9600 baud. Some 3rd party vendor devices might not support all the baud rates supported by the Metasys system. Reducing the baud rate to accommodate these devices affects overall performance.

We recommend setting all MS/TP bus supervisors (NAEs, NCEs, and BACnet Routers) to 38,400.

We recommend setting all field controllers on the FC bus or Remote Field Bus (FACs, FECs, VMA16s, and IOMs) to Auto. In the Auto setting, the Metasys devices listen for the bus supervisor to communicate first; the devices then automatically set their baud rate to the bus supervisor's baud rate. FACs, FECs, VMA16s, and IOMs ship with a default baud rate setting of Auto.

If you anticipate critical peer-to-peer communication and therefore do not want field controllers to wait for the bus supervisor to establish the baud rate, you can specify the baud rate for each device immediately at startup. Choose the baud rate carefully if you use this method, since changing it requires changing each device separately.

TEC26xx Series thermostats automatically set their baud rate to the bus supervisor's baud rate.

Typically, the baud rate setting on bus repeaters and third-party MS/TP devices is configured manually at the device, and the baud rate setting must match the bus supervisor's baud rate. A third-party device that does not support auto-baud establishes the baud rate for the MS/TP network if the NxE is not connected. Refer to the manufacturer's product documentation for information on setting the device's baud rate.

The Metasys software contains the following two device attributes that relate to the baud rate:

- **Baud Rate Selection** allows you to set the baud rate for the device using the System Configuration Tool (SCT) for NAEs, or the Controller Configuration Tool (CCT) for FACs, FECs, VMA16s, and IOMs.
- **Active Baud Rate** allows you to view the baud rate at which the device is communicating on the active bus when Auto baud is selected for the device.

For more information on Metasys system attributes, refer to the Metasys system *Help* (LIT-1201793).

The high baud rates capable on MS/TP buses limit the range of wire gauges used on the bus. The baud rate, wire gauge, wire length, and the number of devices are related. Higher baud rates support more devices but require small gauge wire (which provides lower capacitance). A lower baud rate may be required to use existing, larger gauge wire (which has higher capacitance) but may support fewer devices. We recommend 38,400 baud using 22 AWG stranded wire. This combination provides the best balance between performance and installation sensitivity.

For information on determining wire gauges, wire lengths, and the number of devices supported, see [MS/TP Bus Cable Recommendations](#).

Device Addresses on the MS/TP Bus

Each device connection on an MS/TP bus requires a device address to coordinate communication. Each bus has a set of device addresses that is separate and independent from the device addresses on all other buses. Devices connected to both an MS/TP bus and SA bus have two device addresses, one for each bus connection ([Figure 7](#)).

In the MS/TP bus hierarchy, device connections on separate buses can have the same device address. For example, every bus supervisor connection on an MS/TP bus has a device address of 0 (zero), and the device address for the first network sensor on any SA bus is 199. This is possible because separate buses are identified with different network numbers. [Figure 7](#) shows a simple example of an MS/TP bus and the device addresses for connections on the FC bus and SA bus.

An NAE, NCE, or BACnet Router is the bus supervisor on an FC bus (or Remote Field Bus). The FAC, FEC, VMA16, or the field controller on an NCE is the bus supervisor on an SA bus. Bus supervisors have a fixed device address of 0 (zero) that cannot be changed ([Figure 7](#)). Depending on the model, a network sensor has a fixed address of 199 or an assigned (switch-selectable) address between 200 and 203. [Table 4](#) provides a list of the valid MS/TP device address values and address value ranges for MS/TP devices.

Each MS/TP master controller passes the token to the controller with the next known address. After 50 token passes, each controller searches for other controllers that might have joined the network by attempting to send the token to the controller with the next consecutive address, starting with one higher than its own, until one is found. While you do not need to address devices on the trunk consecutively, you can improve performance by minimizing address skipping. To help with address value selection, see [Table 4](#).

Note: The devices on the bus do not need to be physically wired in sequential order.

Setting a Device Address

For most devices on an MS/TP bus, the (non-supervisory) device address is set by positioning the DIP switches on the device's ADDRESS DIP switch block. The DIP switch blocks are binary switch blocks, with each switch representing a binary numerical value when the switch is in the ON position.

The device address set on the ADDRESS DIP switch block applies to the device connection on the bus where the device is not the bus supervisor. For example, the DIP switches on FACs, FECs, or VMA16s (master devices) set the device address for the device connection to the FC bus (or Remote Field Bus). If the FAC, FEC, or VMA16 also supervise an SA bus, the FAC's, FEC's, or VMA16's address on an SA bus is 0 by default ([Figure 7](#)).

An IOM has only one device connection, which can connect to either an FC bus or an SA bus (but not both); therefore, the device address set on an IOM applies to the bus to which the IOM is connected. (An IOM is never a bus supervisor.)

Figure 7: MS/TP Bus Showing FC Bus and SA Bus Addresses

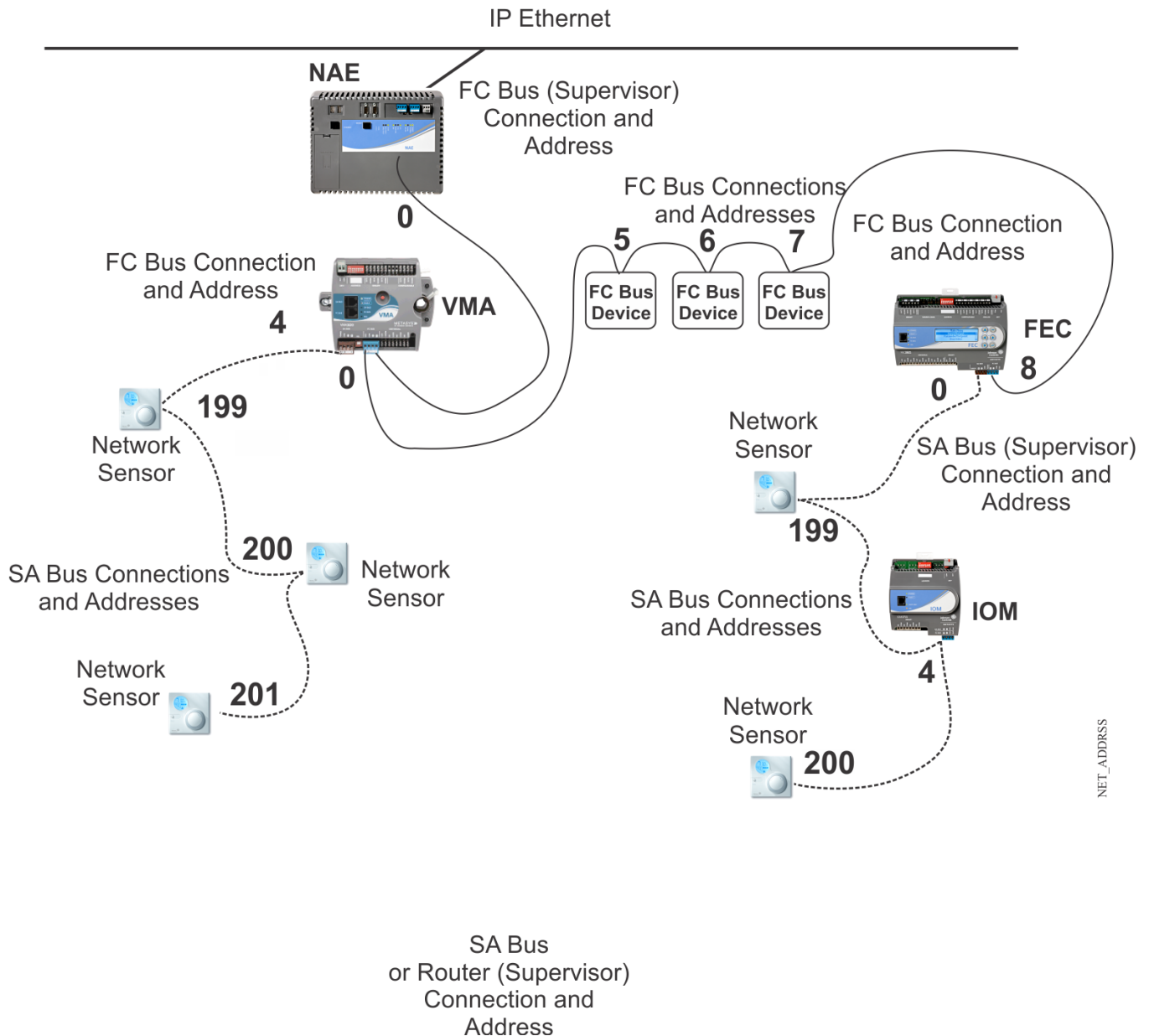


Table 4: Valid MS/TP Bus Address Values and Address Ranges for MS/TP Bus Devices

Address Value/ Address Range	Class	Devices
0	Bus Supervisor	FC Bus: NAE or NCE SA Bus: FAC, FEC, VMA16, or NCE Remote Field Bus: BACnet Router
1	Reserved	Wireless Commissioning Converter (MS-BTCVT-1)
3	Reserved for future use	ZFR1810 Wireless Field Bus Coordinator
120-127	Reserved for future use	
4-127	Master Range	FC Bus: FACs, FECs, VMA16s, IOMs, TECs, and non-FX family devices Remote Field Bus: FACs, FECs, VMA16s, IOMs, TECs, and non-FX family devices SA Bus: IOMs Note: On applications using an NCE, the address value 4 is reserved for the NCE's integral field controller. On applications using ZFR1810 coordinators, address values 120 to 127 are reserved for multiple coordinators.
4-119 (Switch 128 ON)	Reserved	FACs/FECs/IOMs/VMAs: Wireless mode with address range of 4-127 and bit 128 active
128-254	Slave Range	Slave devices, VSDs, and NS network sensors on the SA Bus. Not Supported on the FC Bus.
198	Reserved	VAV Balancing Sensor (handheld)
199	Reserved	Most NS Series Network Sensor models or VAV Balancing Sensor (wall-mounted)
200-203	Reserved	NS Series Network Sensors (specified models)
204-211	Reserved	NS-DTN7043-0 and NS-DTN7083-0 Network Sensors
212-219	Reserved	NS-BCN7004-0 Network CO ₂ Sensor
255	Broadcast	Do not apply address 255 to any device.

Important: On FAC, FEC, VMA16, and IOM Series controllers only, the 128 DIP switch on the controller's device address DIP switch block is a mode switch used to enable the controller to operate in a wireless mode using the ZFR1800 Series Wireless Field Bus System. **On any FAC, FEC, VMA16, or IOM Series controller that is hardwired to an MS/TP Bus, set the 128 DIP switch to the OFF position.** Operating any FAC, FEC, VMA16, or IOM that is hardwired to an MS/TP Bus with the controller's 128 DIP switch set to the ON position results in communication failure on the bus.

As you set the device address, the best practice is to set the highest switch value first, then the next highest switch value, and so on, until the total of the switch values equal the intended device address. For example, positioning switches 16, 4, and 1 to ON (as shown in [Figure 8](#)) sets the device address to 21 for a device on the FC bus.

Figure 8: Setting the Device Address and Wireless Operation Mode on the ADDRESS DIP Switch Block

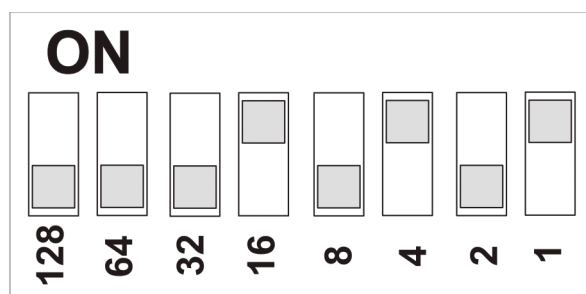


FIG. DIP

Note: You must set switch 128 to OFF on all Metasys controllers that are hardwired to an FC Bus. Set switch 128 to ON only on FACs, FECs, VMA16s, and IOMs that operate on a Metasys ZFR1800 Series Wireless Field Bus.

Note: Devices may go offline momentarily when a device address is changed on an active bus. A device reset is not required on field controllers or supervisory engines after changing the MS/TP address.

Some devices, such as the TEC26xx Series thermostats and third-party MS/TP devices, use their own configuration settings to establish the device address for their connection to the bus. Refer to the device manufacturer's product documentation for instructions on setting the device address. The device address values for TEC26xx thermostats and all third-party devices must comply with the rules and ranges described previously.

Enabling Field Controllers for Wireless Operation

The ZFR1800 Series Wireless Field Bus System enables wireless communication, allowing you to create wireless connections between NAEs or NCEs and FACs, FECs, or VMA16s.

Note: The ZFR1800 Series Wireless Field Bus System **is not** supported on the Remote Field Bus.

On FAC, FEC, and VMA16 controllers, you can enable the controller to operate with a ZFR1800 Series wireless system and connect an MS/TP Bus in a wireless mode by setting the 128 DIP switch on the device address DIP switch block to ON. See [Figure 8](#) for more information.

To operate with a ZFR1800 Series field bus, an FAC, FEC, or VMA16 must be connected to a ZFR1811 Wireless Field Bus Router, and the associated NAE or NCE must be connected to a ZFR1810 Wireless Field Bus Coordinator. See [Related Documentation](#) for references to more information about the ZFR1800 Series Wireless Field Bus System, FACs, FECs, VMA16s, NCEs, and NAEs.

Local FC Bus Rules and Specifications

[Table 5](#), [Table 6](#), and [Figure 9](#) provide rules and specifications for the local FC bus. (For the Remote Field Bus, see [Table 10](#).) Metasys MS/TP devices generate less data traffic than third-party MS/TP devices and TEC26xx thermostats. Connecting third-party devices or TEC26xx thermostats to the FC bus increases data traffic, reduces bus performance, and reduces the number of devices that can be connected to the FC bus.

Table 5: Local FC Bus Rules

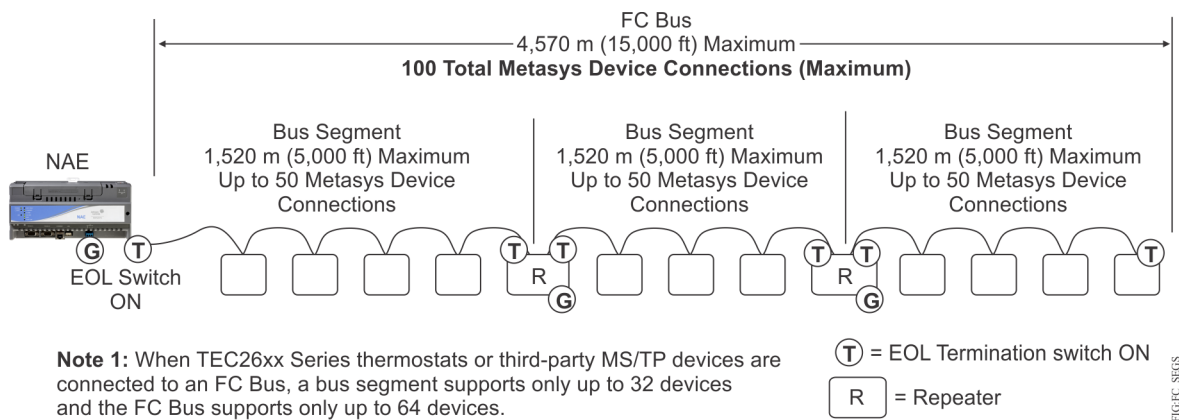
Category	Rules/Limits
General	<p>NAE55 Series models can support up to two local FC buses.</p> <p>Note: When a second FC bus is added to the NAE, be sure the trunk number has not been used on the NAE and enter a Network Address that is unique for the entire site. This applies for any model of NAE.</p> <p>NAE45 Series models can support one local FC bus.</p> <p>NAE35 Series models can support one local FC bus (but an NAE35 FC bus supports only half the number of devices that are supported on an FC bus on an NAE45 or NAE55).</p> <p>NCE25 Series models can support one local FC bus. NCEs must be ordered specifically as N2 or MS/TP models.</p> <p>Note: An FC port on an NAE/NCE can connect to only one bus segment on an FC bus. Only a daisy-chain topology is allowed (no T or Star topology configurations).</p> <p>Note: Refer to the <i>Network Automation Engine (NAE) Product Bulletin (LIT-1201160)</i> and the <i>Network Controller Engine Product Bulletin (LIT-12011283)</i> for complete information on MS/TP bus support on NAE and NCE models.</p>
Number of Devices and Bus Segments	<p>NCE25 models support 32 MS/TP devices (maximum) on an FC bus trunk and up to 3 bus segments.</p> <p>NAE35 models support half the number of devices that an NAE45 supports.</p> <p>NAE45 and NAE55 models support the following device limits on an FC bus trunk:</p> <p>When all of the devices connected on the FC bus are Metasys FACs, FECs, VMA16s, and/or IOMs, the device and bus segment limits are as follows:</p> <ul style="list-style-type: none"> • 100 devices total per FC bus (maximum) • 3 bus segments per FC bus (maximum) • 50 devices per bus segment (maximum, not to exceed 100 devices per FC bus) <p>When one or more non-FX family device is connected on the FC bus, the device and bus segment limits are as follows:</p> <ul style="list-style-type: none"> • 64 devices total per FC bus (maximum) • 3 bus segments per FC bus (maximum) • 32 devices per bus segment (maximum, not to exceed 64 devices per FC bus) <p>Bus segments on an FC bus are connected with repeaters (only). Up to two cascaded repeaters may be applied to an FC bus (to connect three bus segments).</p>
Cable Length for FC Bus and Bus Segments	<p>When all of the devices connected on the FC bus are Metasys FACs, FECs, VMA16s, or IOMs, the cable length limits (using 22 AWG 3-wire twisted, shielded cable) are as follows:</p> <ul style="list-style-type: none"> • Each bus segment can be up to 1,520 m (5,000 ft) in length. • Each FC bus can be up to 4,750 m (15,000 ft) in length. <p>When one or more non-FX family device is connected on the FC bus, the device and bus segment limits are as follows:</p> <ul style="list-style-type: none"> • Each bus segment can be up to 1,220 m (4,000 ft)¹ in length. • Each FC bus can be up to 3,660 m (12,000 ft)¹ in length. <p>Note: Do not place slave devices on the FC Bus. Slave devices on the FC bus are not supported.</p> <p>When using fiber-optic connections: 2,010 m (6,600 ft)¹ between two fiber modems.</p>

Table 5: Local FC Bus Rules

Category	Rules/Limits
Recommended Cable²	22 AWG Stranded, 3-Wire Twisted, Shielded Cable
EOL Termination	The EOL switch must be set to On (or an EOL terminator installed) on the two devices located at either end of each bus segment on an FC bus. The EOL switches must be set to Off (or EOL termination disabled) for all other devices on the bus segment on an FC bus. See EOL Termination on the Local FC Bus for more information.

- 1 If third-party devices are connected to the bus, the cable lengths should be reduced (if necessary) to match the third-party vendor recommendations.
- 2 The recommended cable type provides the best bus performance. See [MS/TP Bus Cable Recommendations](#) for information on alternative cable types and lengths that may be used in MS/TP applications.

Figure 9: FC Bus with Three Bus Segments Connected with Repeaters



Note 1: When TEC26xx Series thermostats or third-party MS/TP devices are connected to an FC Bus, a bus segment supports only up to 32 devices and the FC Bus supports only up to 64 devices.

Note 2: For optimum noise protection the locations with G are the ideal shield grounding locations. This provides one shield ground per bus segment, grounding at the source of the bus for that segment. It is also acceptable to ground the shield only at the NAE if the shields are made continuous across repeaters side A and B; however, the noise protection is somewhat less with this wiring configuration.

Note 3: While each bus segment can support up to 50 Metasys Device connections, the total on the FC Bus cannot exceed 100, including the NAE.

The bus segments on an FC bus are connected using repeaters (only). A repeater has two device connections, which are independent of each other. Each device connection on the repeater is connected to a bus segment just like any other device connection on the segment, and a repeater device connection can be connected at the end of a bus segment or anywhere along the segment. When a repeater device connection is at the end of a bus segment, EOL termination must be enabled on that repeater device connection. See [Figure 10](#) for more examples of repeaters on FC buses.

Table 6: FC Bus Specifications

Category	Specification
Error Checking	Message Headers checked using 8-bit Cyclic Redundancy Check (CRC) test. Message data check using 16-bit CRC test.
Device Addressing	0–255 (See Device Addresses on the MS/TP Bus for more information.)
Data Transmission Standard	RS485
Signaling Method	BACnet® MS/TP
Signaling Rate	9600; 19,200; 38,400; or 76,800 baud as selected by bus supervisor. (See Baud Rates on the MS/TP Bus .)

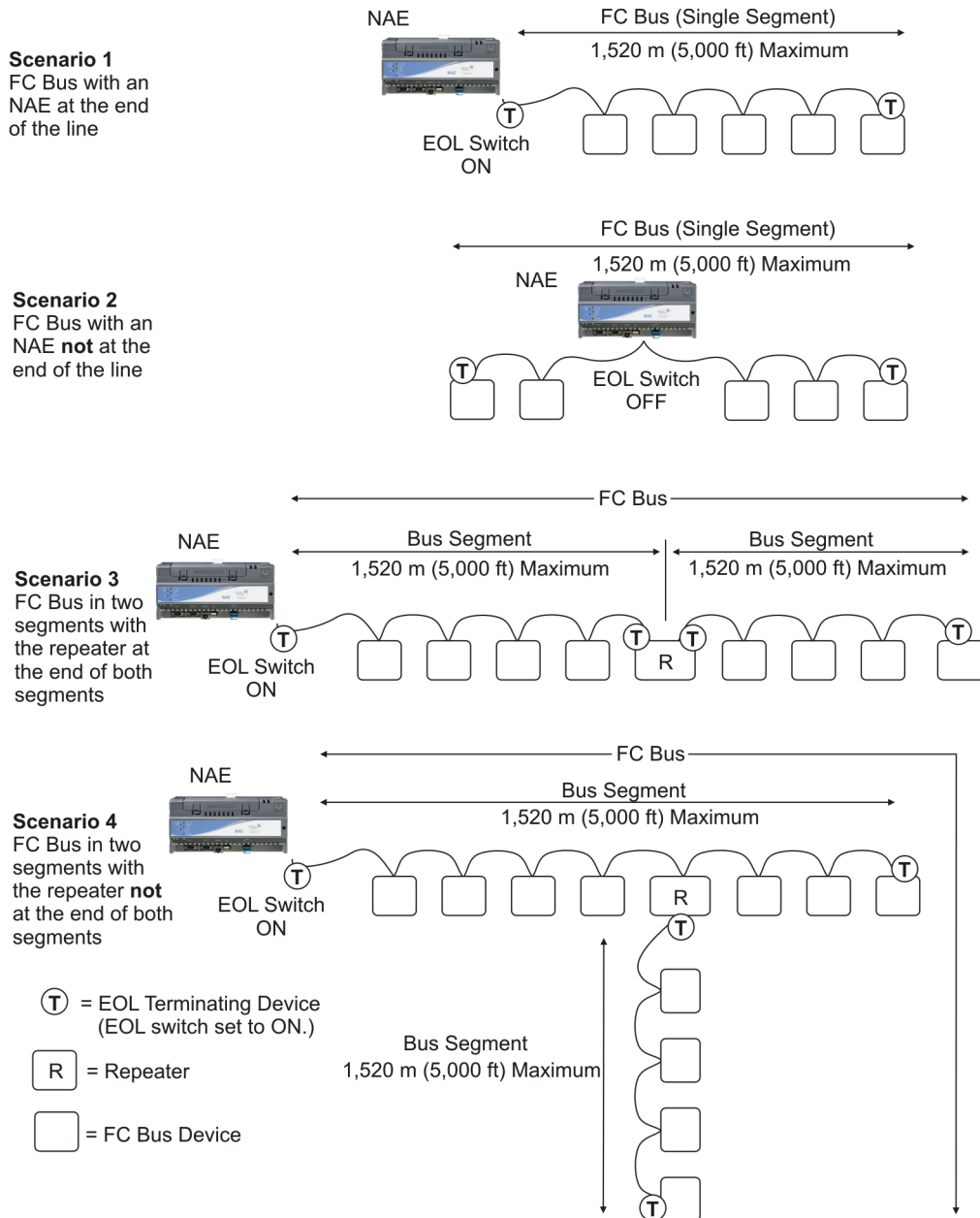
Table 6: FC Bus Specifications

Category	Specification
Transient Immunity	Meets EN61000-4-4 and EN6100-4-5 requirements for heavy industrial applications. Protected against misapplication of 24 VAC.
EOL Termination Method	Integral EOL Termination switch or add-on EOL Terminator module (See EOL Termination on the Local FC Bus.) Do not use third-party EOL termination.
Shield Grounding	Only one hard ground connection per bus segment when using shielded cable. (See Grounding the Bus Cable Shield.)
Physical Configuration	Daisy-chained
Optional Vendor Components	<p>Repeaters</p> <ul style="list-style-type: none"> Acromag 4683-TTM-1F (115 VAC) Acromag 4683-TTM-2F (230 VAC) Acromag 4683-TTM-3F (24 VAC) <p>Note: A repeater is required to support more than 50 devices per trunk segment or trunk cable segment longer than 1,524 m (5,000 ft). Only the listed Acromag 4683 series repeaters provide EOL termination switching that is compatible with Metasys MS/TP.</p> <p>Transient Eliminator</p> <p>Advanced Protection Technologies Transient Eliminator TE/JC04C12</p> <p>Fiber Modem</p> <ul style="list-style-type: none"> S.I. Tech 2110 Fiber-Optic Modem and S.I. Tech 2121 Power Supply 9-pin Male Connector Kit (required by 2110 modem) Does not support 76,800 baud

EOL Termination on the Local FC Bus

The FC bus requires EOL termination at the end of each bus segment. [Figure 10](#) shows four examples of EOL termination on the FC bus.

Figure 10: FC Bus Segment EOL Termination Scenarios



Note: Set the EOL termination switch on a repeater's device connection to ON only when the repeater connection terminates a bus segment. See Scenarios 3 and 4 in [Figure 10](#).

Note: Third-party MS/TP devices and TEC26xx Series thermostats have different EOL termination requirements on the FC bus. See [TEC26xx Series Thermostats and Third-Party MS/TP Devices](#) for more information.

EOL Terminator Module

The MS-BACEOL-0 RS485 EOL Terminator provides EOL termination on FC bus segments when the device connected at the end of a bus segment does not have integral EOL termination capability.

The EOL terminator is a compact, lightweight, module wrapped in a protective cover that can be quickly installed in a variety of ways. The EOL connects directly to the terminating device on a bus segment with the attached wire leads. The EOL requires 24 VAC, Class 2 power supplied by the field device or other 24 VAC source.

An EOL terminator is required in all Metasys MS/TP applications wherever a terminating device on an FC bus segment does not have integral EOL termination (for example, TEC26xx Series thermostats).

The EOL terminator is designed for FC buses and provides better bus performance than the integral EOL termination on third-party devices. An EOL is recommended wherever a third-party device terminates an FC bus segment. If the EOL terminator is connected to a third-party device that has integral EOL termination, the integral EOL termination on the third-party device must be disabled.

TEC26xx Series Thermostats and Third-Party MS/TP Devices

TEC26xx Series thermostats and third-party MS/TP devices generate more data traffic than Metasys MS/TP devices. Increased data traffic reduces FC bus performance and reduces the number of devices that can be connected to the bus. When any of these devices are connected on an FC bus, different device and cable length limits apply to the bus and bus segments.

If one or more TEC26xx Series thermostat and third-party BACnet® MS/TP device are connected on an FC bus, the supported maximum device counts, bus segments, and bus length are as follows:

- 64 devices total per FC bus (maximum)
- 3 bus segments per FC bus (maximum)
- 32 devices per bus segment (maximum, not to exceed 64 devices total on FC bus)
- 1,220 m (4,000 ft) maximum per bus segment (using 22 AWG stranded, 3-wire twisted, shielded cable)
- 3,660 m (12,000 ft) maximum per FC bus (using 22 AWG stranded, 3-wire twisted, shielded cable)

TEC26xx Series thermostats and third-party MS/TP devices also have different EOL termination requirements. When a TEC26xx thermostat is at the end of a bus segment, an EOL Terminator must be wired to the FC bus terminals on the TEC26xx thermostat. Third-party devices should not be connected to the end of a bus segment unless the third-party device's EOL termination capability is disabled and an EOL Terminator is wired to the bus terminations at the third-party device.

SA Bus Rules and Specifications

The SA bus connects IOMs, VSDs, and NS-Series network sensors to field controllers. [Figure 11](#) shows three SA bus examples. [Table 7](#) and [Table 8](#) provide SA bus rules and specifications.

Table 7: SA Bus Rules

Category	Rules/Limits
General	Each bus supervisor supports one SA Bus (and each SA Bus is a single segment).
Number of Devices Supported on the Bus	<p>An SA Bus supports up to 10 devices. The SA bus supervisor provides power for all slave devices connected to the SA bus, including up to four NS network sensors. IOMs connected to the SA bus are not powered by the bus supervisor.</p> <p>Note: Exceeding the SA bus power limit can result in devices going offline and poor bus performance. See SA Bus Device Limits for more information on SA bus power limits.</p> <p>SA Buses do not support repeaters.</p>
Cable Length	<p>365 m (1,200 ft) maximum bus length</p> <p>152 m (500 ft) maximum distance between an NS network sensor and the bus supervisor (FAC, FEC, or VMA16 supplying power to the sensor) using bus cable connected to the SA Bus screw terminal blocks</p> <p>30 m (100 ft) maximum length for network sensors using bus cables connected to the RJ-Style modular jack (6-Pin SA Bus Port)</p> <p>366 m (1,200 ft) maximum bus length</p>
Recommended Cable Type¹	<p>Screw Terminal Connections: 22 AWG Stranded 4-wire, 2-Twisted Pairs, Shielded Cable for screw terminals.</p> <p>Modular Jack Connections: 6-Pin RJ-Style Modular Connectors with 24 or 26 AWG Solid 6-Wire, 3 Twisted-Pairs</p>
EOL Termination	Each SA bus supervisor has integral (fixed ON) EOL termination, which typically provides sufficient EOL termination on an SA bus. Long SA bus runs or persistent communication problems on an SA bus may require EOL termination at the last device on the SA bus (in addition to the integral EOL termination at the SA bus supervisor).
Mixing Device Types	Do not mix RJ-style modular (phone) jack devices and screw terminal devices on the SA bus.

- ¹ The recommended cable types provide the best bus performance. See [MS/TP Bus Cable Recommendations](#) for information on alternative cable types.

Table 8: SA Bus Specifications

Category	Specification
Error Checking	<p>Message Headers checked using 8-bit CRC test.</p> <p>Message data check using 16-bit CRC test.</p>
Device Addressing	0–255 (See Device Addresses on the MS/TP Bus for more information.)
Data Transmission Standard	RS485
Signaling Method	BACnet® MS/TP
Signaling Rate	9600; 19,200; 38,400 (default); or 76,800 baud as selected by the bus supervisor
Transient Immunity	Meets EN61000-4-4 and EN6100-4-5 requirements for heavy industrial applications. Protected against misapplication of 24 VAC.
Shield Grounding	One hard ground per bus segment when using shielded cable
Physical Configuration	Daisy-chained (screw terminal only).

SA Bus Device Limits

The SA Bus is limited to 10 devices total to ensure good communication on the bus and is limited to four NS sensors because only four unique addresses can be set on the sensors. Due to change of value (COV) limitations, it is best to limit the number of IOMs on the SA Bus to four. The SA bus is also limited by the total power consumption of the devices connected on the bus. Exceeding the total power consumption limit can cause poor bus communication and cause devices to go offline.

Table 9 provides the power consumption of devices commonly connected to the SA bus.

Important: The total power consumption on an SA Bus is limited to 210 mA; do not exceed the SA Bus power consumption limit. Exceeding the total power consumption limit can cause poor bus communication and cause devices to go offline.

Table 9: Power Consumption by Common SA Bus Devices

SA Bus Device	Power Consumption on the SA Bus
Discharge Air Sensors (NS-DTN70x3-0)	12 mA
Balancing Sensors (NS-DTN70x3-0)	12 mA
Network Sensors without display	13 mA
Network Sensors with display no RH	21 mA
Network Sensors with display and RH	27 mA
CO2 Network Sensors (NS-BCN7004-0)	28 mA (non-isolated) or 5 mA (isolated)
ZFR1811 Wireless Field Bus Router	90 mA
DIS1710 Local Controller Display	90 mA - may be a temporary load
Wireless Commissioning Converter	90 mA - temporary load
Variable Speed Drives	NA (self-powered)
IOM Series Controllers	NA (self-powered)
Romutec® Modules	NA (self-powered)

SA bus applications are limited to a power load of 210 mA.

The best practice when configuring an SA bus is to limit the total available operating power consumption to 120 mA or less. This power level allows you to **temporarily** connect a Wireless Commissioning Converter or a DIS1710 Local Controller Display to the bus for commissioning, adjusting, and monitoring.

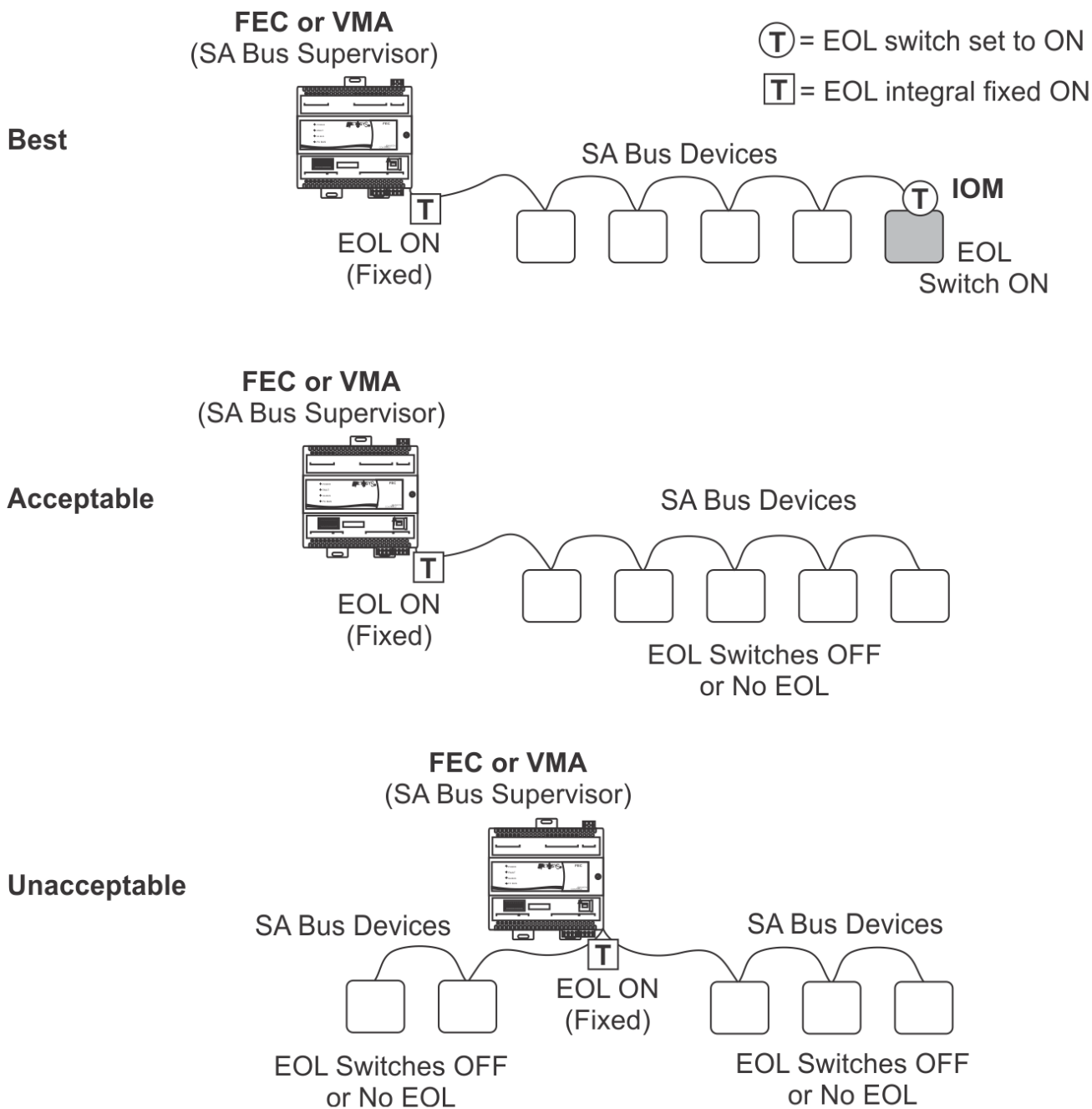
On SA bus applications where a DIS1710 display or ZFR1811 Wireless Field Bus Router is permanently connected to the bus, limit the additional available operating power consumption to 30 mA, to allow for the temporary use of a Wireless Commissioning Converter on the bus.

For example, if the ZFR1811 uses 90 mA and the Wireless Commissioning Converter uses 90 mA, you have 30 mA available for additional loads: 90 mA + 90 mA + 30 mA = 210 mA total.

EOL Termination on the SA Bus

On an SA bus, the minimum requirement is that EOL termination **must** be enabled on at least one device. Since an SA bus supervisor always has EOL termination enabled, this requirement is always met; however, for enhanced bus performance, we recommend that you enable EOL termination on the devices at each end of the SA bus. See [Figure 11](#) for SA bus EOL termination scenarios.

Figure 11: SA Bus EOL Termination Scenarios



Note: The MS-BACEOL-0 RS485 End-of-Line Terminator module is not designed for EOL termination on the SA bus.

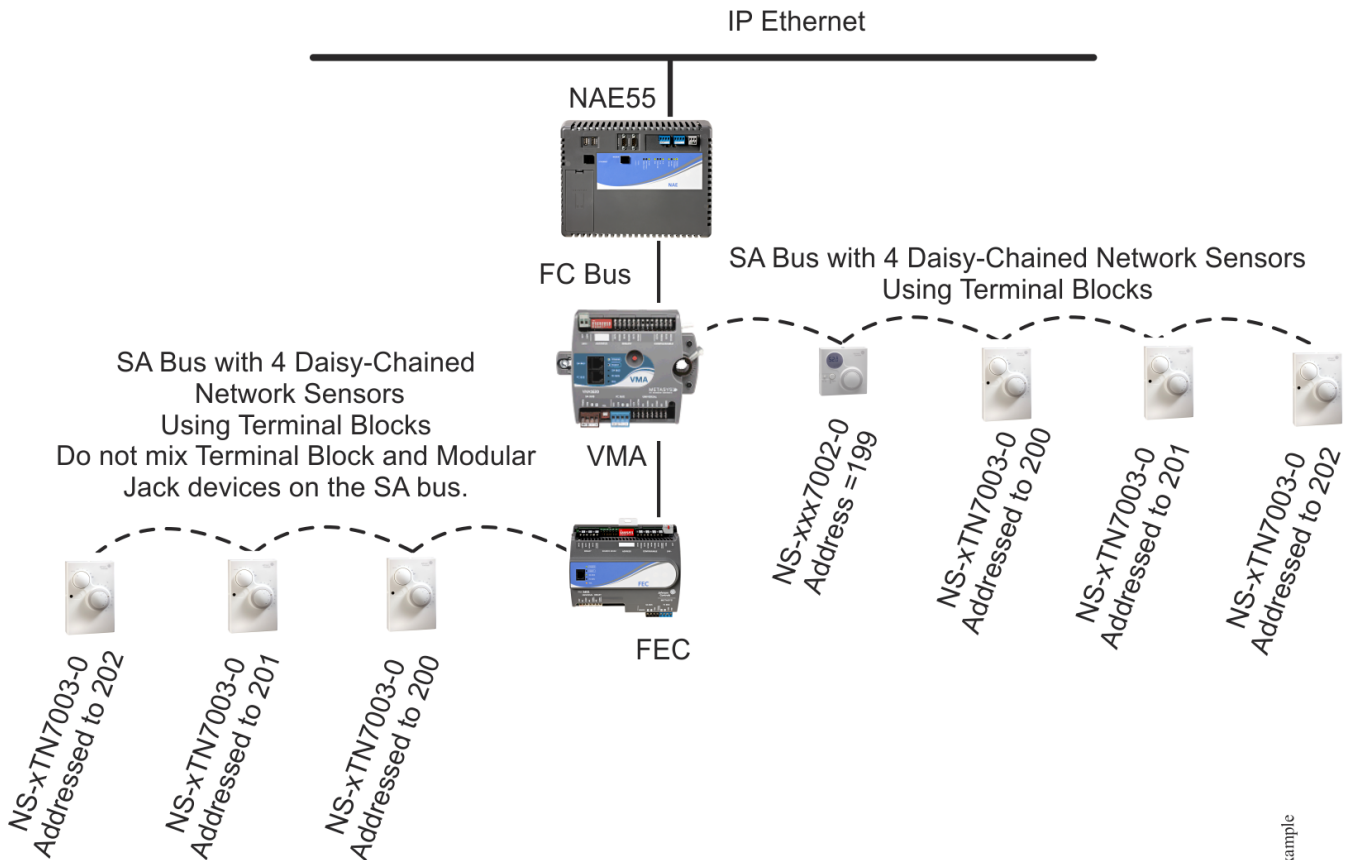
SA Buses with Multiple Network Sensors

An SA bus supports up to four network sensors. [Figure 12](#) shows an example of two SA buses, each with four network sensors. To place multiple network sensors on the bus, three of the network sensors must be DIP switch addressable.

Note: Do not mix RJ-style modular (phone) jack and screw terminal devices on the SA bus. Due to the permanent internal SA bus EOL termination contained in FECs, FACs, IOMs, and VMAs, using both the phone jack and terminal block effectively puts the EOL termination in the middle of the SA trunk, creating a star network configuration. This configuration violates the RS-485 network wiring guidelines and can cause unpredictable communication problems.

Some NS Series Network Sensors and NS Series Discharge Air Sensors models are DIP switch addressable.

Figure 12: SA Bus Example Showing Multiple Networks Sensors



FIG_ins_example

Remote Field Bus Rules and Specifications

Table 10 provides rules for the Remote Field Bus (RFB). In addition to these rules:

- Configure the BACnet Router **before** you connect it to the building network. If the BACnet Router is commissioned using IP, use an Ethernet patch cable.
- For each Remote Field Bus you add to an NAE, make sure the trunk number has not been used on the NAE. Enter a Network Address between 1 and 65534 that is unique for the site. Use trunk numbers 3 to 20 to configure Remote Field Buses to the NAE. (Trunk numbers 1 and 2 are reserved for the local field buses.)
- Connect the MS/TP port of the BACnet Router to only one bus segment on the Remote Field Bus. Only a daisy-chain topology is allowed on the Remote Field Bus (no T or Star topology configurations). See [Figure 9](#) for an example of bus segments.
- If you create a new remote field bus with SCT by copying an existing remote field bus, you need to change the Remote Field Bus trunk number because the number in the copied bus always reverts to 1.
- BACnet Broadcast Management Devices (BBMDs) may be required to allow BACnet IP broadcast messages to reach the BACnet Router. BACnet IP broadcast messages are used to determine the BACnet Router's IP address.
- Define only one Remote Field Bus for each BACnet Router. Performance may be severely reduced if more than one Remote Field Bus or integration is assigned to the same BACnet Router.
- Do not split the mapping of remote MS/TP devices from a single BACnet Router into more than one Remote Field Bus or integration. Use only one integration to map all devices from the MS/TP side of the BACnet Router.

Table 10: Remote Field Bus Rules

Category	Rules/Limits
General	<p>Total number of field buses (RFB and FC bus):</p> <p>NAE55: 8 (6 RFB + 2 FC or 7 RFB + 1 FC)</p> <p>NAE45: 4 (3 RFB + 1 FC)</p> <p>NAE35: 4 (3 RFB + 1 FC)</p> <p>NCE25: 1 (1 FC; does not support Remote Field Bus)</p> <p>NAE85: 16 RFB only</p> <p>NAE-Lite: 2 (1 RFB + 1 FC)</p> <p>ODS: 16 RFB only</p>
Number of Devices and Bus Segments	<p>Total number of remote field devices per Router:</p> <p>32: if all connected devices are Metasys products</p> <p>16: if one or more connected devices are manufactured by a third-party vendor</p> <p>Note: To take advantage of MS/TP diagnostics, you must add at least one Metasys field device (FEC, FAC, VMA16, or IOM) to the Remote Field Bus as an FEC Family device.</p> <p>Bus segments on a Remote Field Bus are connected with repeaters (only). Up to two cascaded repeaters may be applied to a Remote Field Bus (to connect three bus segments).</p>

Table 10: Remote Field Bus Rules

Category	Rules/Limits
Cable Length for FC Bus and Bus Segments	<p>When all of the devices connected on the Remote Field Bus are Metasys FACs, FECs, VMA16s, or IOMs, the cable length limits (using 22 AWG 3-wire twisted, shielded cable) are as follows:</p> <ul style="list-style-type: none"> Each bus segment can be up to 1,520 m (5,000 ft) in length. Each RFB can be up to 4,750 m (15,000 ft) in length. <p>When one or more third-party family device is connected on the Remote Field Bus, the device and bus segment limits are as follows:</p> <ul style="list-style-type: none"> Each bus segment can be up to 1,220 m (4,000 ft)¹ in length. Each RFB can be up to 3,660 m (12,000 ft)¹ in length. <p>Note: Do not place slave devices on the Remote Field Bus. Slave devices on the Remote Field Bus are not supported.</p> <p>When using fiber-optic connections: 2,010 m (6,600 ft)¹ between two fiber modems.</p>
Network Number and Instance Number for Router	<p>BACnet Network Number assigned to the IP side of the Router must match the BACnet IP network number used in the supervisory engines. The default IP network number is 1001. Do not use 2000 or 65000 as the network number; these numbers are used for existing embedded networks.</p> <p>BACnet Network Number assigned to the MS/TP side of the BACnet Router must be unique on the site across the entire BACnet Site. This may include multiple buildings, cities, states, and even countries. It is very important to know the network to which you are adding one of these routers.</p> <p>Device Instance Number assigned to the BACnet Router must be unique on the site.</p>
BACnet Router Settings	<p>Follow the manufacturers instructions to configure the BACnet Router's IP address, BACnet Device ID, MS/TP Network Number, and BBMD. Note that some routers do not have a device object in which a device name and id is required.</p> <p>Set Max Info Frames = 80 to 100 (all devices are Johnson Controls field devices) or 20 (some or all devices are third-party field devices)</p>
Recommended Cable²	22 AWG Stranded, 3-Wire Twisted, Shielded Cable
EOL Termination	<p>The EOL switch must be set to On (or an EOL terminator installed) on the two devices located at either end of each bus segment on a Remote Field Bus. Use an EOL terminator for the BACnet Router as it has no EOL switch. The EOL switches must be set to Off (or EOL termination disabled) for all other devices on the bus segment on a Remote Field Bus. See EOL Termination on the Remote Field Bus for more information.</p>

- 1 If third-party devices are connected to the bus, the cable lengths should be reduced (if necessary) to match the third-party vendor recommendations.
- 2 The recommended cable type provides the best bus performance. See [MS/TP Bus Cable Recommendations](#) for information on alternative cable types and lengths that may be used in MS/TP applications.

The Remote Field Bus requires EOL termination at the end of each bus segment. [Figure 13](#) shows four examples of EOL termination on the remote FC bus.

Scenario 1
RFB with Router at the end of the line.

BACnet IP Router

RFB (Single Segment)
1,520 m (5,000 ft) Maximum

EOL Terminator Installed

Scenario 2
RFB with a Router **not** at the end of the line.

RFB (Single Segment)
1,520 m (5,000 ft) Maximum

BACnet IP Router

No EOL Terminator

Scenario 3
RFB in two segments with the repeater at the end of both segments.

BACnet IP Router

RFB

Bus Segment
1,520 m (5,000 ft) Maximum

Bus Segment
1,520 m (5,000 ft) Maximum

EOL Terminator Installed

R

Scenario 4
RFB in two segments with the repeater **not** at the end of both segments

BACnet IP Router

RFB

Bus Segment
1,520 m (5,000 ft) Maximum

EOL Terminator Installed

R

Bus Segment
1,520 m (5,000 ft) Maximum

Legend:

- (T) = EOL Terminating Device (EOL switch set to ON.)
- (R) = Repeater
- [] = Field Device

Note: Third-party MS/TP devices and TEC26xx Series thermostats have different EOL termination requirements on the Remote Field Bus. See [TEC26xx Series Thermostats and Third-Party MS/TP Devices](#) for more information.

EOL Terminator Module for Remote Field Bus

An EOL terminator is required in all Metasys MS/TP applications wherever a terminating device on a Remote Field Bus segment does not have integral EOL termination (for example, TEC26xx Series thermostats and some BACnet IP Routers).

For Metasys devices without a built-in EOL switch, use the MS-BACEOL-0 RS485 EOL Terminator. The EOL terminator is a compact, lightweight module wrapped in a protective cover that can be quickly installed in a variety of ways. The EOL connects directly to the terminating device on a bus segment with the attached wire leads. The EOL requires 24 VAC, Class 2 power supplied by the field device or other 24 VAC source.

For the Loytec Router, use the L-Term LT-04 Bus Terminator. The terminator requires no external power supply. Refer to the Loytec website (<http://www.loytec.com>) for additional details.

MS/TP Bus Cable Recommendations

The MS/TP bus supports much higher baud rates than the N2 bus. Higher baud rates make the MS/TP bus less fault tolerant and less immune to interference from inductive noise sources that may be present in the application environment.

For the best performance on MS/TP bus applications, use 22 AWG stranded wire in a shielded cable with proper cable shield grounding. This recommendation applies to both local and Remote Field Bus installations. Other wire gauges and non-shielded cable **may** provide acceptable bus performance in many applications, especially applications that have short cable runs and low ambient inductive noise levels.

[Table 11](#) provides cable recommendations for MS/TP applications. The recommended FC bus and SA bus cables are available from Belden CDT Inc. and Anixter, Inc.

Alternative cables may be used in MS/TP applications. [Table 12](#) provides information regarding the relationship between baud rate, wire gauge, wire length, and supported device numbers. You can also use the information provided in [Table 12](#) to determine if existing cable runs may be used in a retrofit or upgrade MS/TP application.

Note: In [Table 11](#), the shielded bus and cable types are **recommended**; the non-shielded bus and cable types are **acceptable**.

Table 11: Cable for FC Buses and SA Buses in Order of Preference

Bus and Cable Type	Non-Plenum Applications		Plenum Applications	
	Part Number	O.D.	Part Number	O.D.
FC Bus: 22 AWG Stranded, 3-Wire Twisted Shielded Cable ¹	Anixter: CBL-22/3-FC-PVC Belden®: B5501FE	0.138 in.	Anixter: CBL-22/3-FC-PLN Belden: B6501FE	0.140 in.
SA Bus (Terminal Block): 22 AWG Stranded, 4-Wire, 2 Twisted-Pair Shielded Cable ¹	Anixter: CBL-22/2P-SA-PVC Belden: B5541FE	0.209 in.	Anixter: CBL-22/2P-SA-PLN Belden: B6541FE	0.206 in.
SA Bus (Modular Jack): 26 AWG Solid 6-Wire, 3 Twisted-Pair Cable ²	—	—	Anixter preassembled: CBL-NETWORK25 CBL-NETWORK50 CBL-NETWORK75 CBL-NETWORK100	0.15 in.
FC Bus: 22 AWG Stranded, 3-Wire Twisted Non-Shielded Cable	Belden: B5501UE	0.135 in.	Belden: B6501UE	0.131 in.
SA Bus (Terminal Block): 22 AWG Stranded, 4-Wire, 2 Twisted-Pair Non-Shielded Cable	Belden: B5541UE	0.206 in.	Belden: B6541UE	0.199 in.

- 1 We strongly recommend 3-wire (for FC Bus) and 4-wire, 2 twisted-pair (for SA Bus), 22 AWG stranded, shielded cable. A 22 gauge cable offers the best performance for various baud rates, cable distances, and number of trunk devices primarily due to lower conductor-to-conductor capacitance. Shielded cable offers better overall electrical noise immunity than non-shielded cable. Observe the shield grounding requirements.
- 2 We recommend 26 AWG solid, 6-wire (3 twisted pairs) cable as the best fit for fabricating modular cables with the modular jack housing assembly. Be sure the cable you use fits the modular jack housing. The preassembled cables that are available from Anixter (Part No. CBL-NETWORKxxx) use 24 gauge wire.

Table 12: FC Bus Wire Gauge and FC Bus Baud Rate

AWG Wire Gauge	Maximum Cable Length and Node Connections Limit	Baud Rate					
		9600 ¹	19,200 ¹	38,400 ²		76,800 ³	
18	Maximum Cable Length per Bus Segment (m [ft])	1,524 (5,000) (APR)	1,524 (5,000) (APR)	1,219 (4,000) (NR)	1,219 (4,000) (NR)	609 (2,000) (NR)	305 (1,000) (NR)
	Maximum Number of Nodes (per Segment / per FC Bus)	25/25 (APR)	50/50 (APR)	40/100 (NR)	50/100 (NR)	10/30 (NR)	50/100 (NR)
20	Maximum Cable Length per Bus Segment (m [ft])	1,524 (5,000) (APR)	1,524 (5,000) (APR)	1,524 (5,000) (APR)		1,524 (5,000) (NR)	1,219 (4,000) (NR)
	Maximum Number of Nodes (per Segment / per FC Bus)	25/25 (APR)	50/50 (APR)	50/100 (APR)		40/100 (NR)	50/100 (NR)

Table 12: FC Bus Wire Gauge and FC Bus Baud Rate

22	Maximum Cable Length per Bus Segment (m [ft])	1,524 (5,000) (A)	1,524 (5,000) (A)	1,524 (5,000) (Best)	1,524 (5,000) (A)
	Maximum Number of Nodes (per Segment / per FC Bus)	25/25 (A)	50/50 (A)	50/100 (Best)	50/100 (A)
24	Maximum Cable Length per Bus Segment (m [ft])	1,524 (5,000) (APR)	1,524 (5,000) (APR)	1,524 (5,000) (APR)	1,524 (5,000) (APR)
	Maximum Number of Nodes (per Segment / per FC Bus)	25/25 (APR)	50/50 (APR)	50/100 (APR)	50/100 (APR)
26	Maximum Cable Length per Bus Segment (m [ft])	1,524 (5,000) (APR)	1,524 (5,000) (APR)	1,524 (5,000) (APR)	1,524 (5,000) (APR)
	Maximum Number of Nodes (per Segment / per FC Bus)	25/25 (APR)	50/50 (APR)	50/100 (APR)	50/100 (APR)
A = Acceptable APR = Acceptable with Possible Restrictions NR = Not Recommended					

- 1 The maximum number of devices is reduced at lower baud rates due to increased token loop times.
- 2 3-wire conductor (FC Bus), 22 AWG stranded, shielded cable is recommended. 22 gauge cable offers the best performance for various baud rates, cable distances, and number of trunk devices primarily due to lower conductor-to-conductor capacitance. Shielded cable offers better overall electrical noise immunity than non-shielded cable.
- 3 The MS-NAE55xx-0 cannot communicate at 76,800 baud.

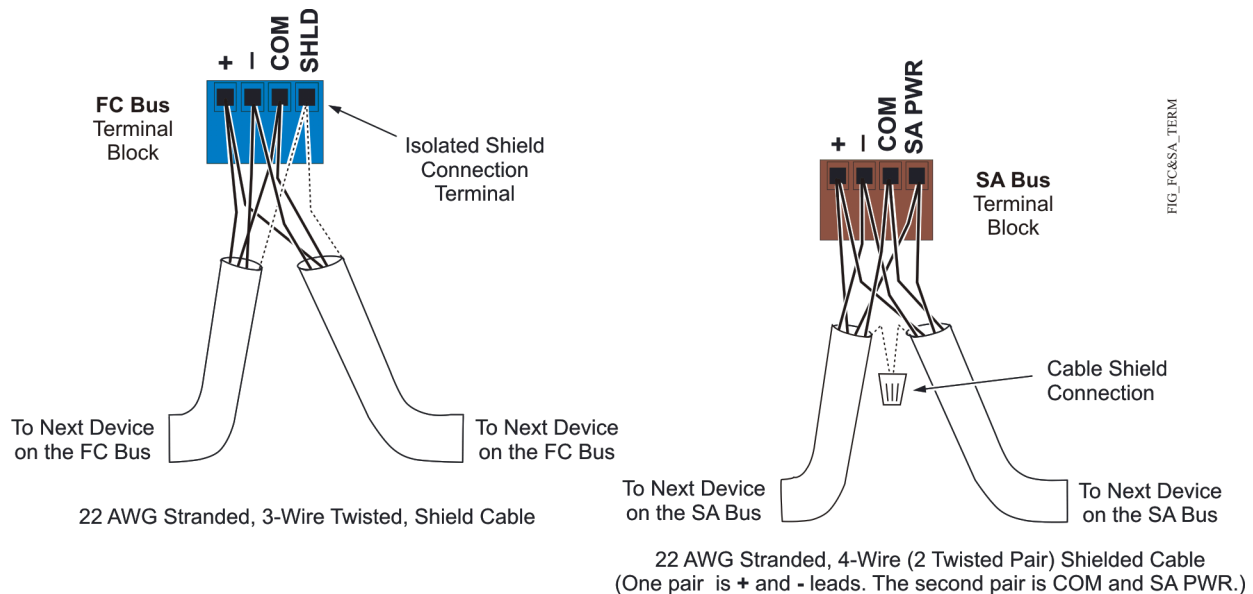
Screw Terminal Blocks for Connecting the Bus Cable

Both the FC bus and SA bus terminations have pluggable screw terminal blocks that allow you to connect the bus devices in a daisy-chain configuration. Connect the devices to the FC bus segments and SA bus as shown in [Figure 14](#).

Note: The SHLD terminal on the FC bus terminal block is electrically isolated from ground and is provided as a convenient terminal for connecting the cable shield in a daisy-chain on the bus segment.

Note: Do not mix RJ-style modular (phone) jack and screw terminal devices on the SA bus. Due to the permanent internal SA bus EOL termination contained in FECs, FACs, IOMs, and VMAs, using both the phone jack and terminal block effectively puts the EOL termination in the middle of the SA trunk, creating a star network configuration. This configuration violates the RS-485 network wiring guidelines and can cause unpredictable communication problems.

Figure 14: FC Bus and SA Bus Terminal Block Wiring Details



Grounding the Bus Cable Shield

Inductive interference and Radio Frequency (RF) interference can adversely affect MS/TP applications, causing poor bus performance and frequent device offline occurrences. Experience has shown that installing a properly grounded shielded bus cable in MS/TP applications greatly reduces the impact of ambient inductive noise and RF interference. Applications installed without shielded cable are much less tolerant to ambient interference.

We recommend installing MS/TP bus applications using shielded cable. In applications using shielded cable, it is very important to ground the cable shield properly. Improper shield grounding can also result in poor bus performance and frequent device offline occurrences.

To properly ground the cable shield on an MS/TP application, the cable shields on each **bus segment** must be connected in a daisy-chain as shown in [Figure 14](#). Each daisy-chained segment must be connected at **one** point (only) to a hard ground connection. We recommend connecting the cable shield to hard ground close to the bus supervisor's bus terminations. In metal panel or enclosure applications, connect the cable shield to ground where the bus cable enters the panel or enclosure that contains the bus supervisor. On bus segments without a bus supervisor, the best practice is to connect the cable shield to hard ground at a bus device near the middle of the bus segment.

Important: Ensure that the cable shield is **connected to hard ground at only one point on the bus segment** and is completely isolated from hard ground at all other points. Multiple hard ground connections on a bus segment can create ground loop currents in the cable shield, resulting in poor bus performance and frequent device offline occurrences.

In certain environments with high ambient inductive interference or strong radio frequency transmissions, an MS/TP application may require the addition of soft ground connections along the bus segments to enhance bus performance and reduce device offline occurrences, or possible device damage.

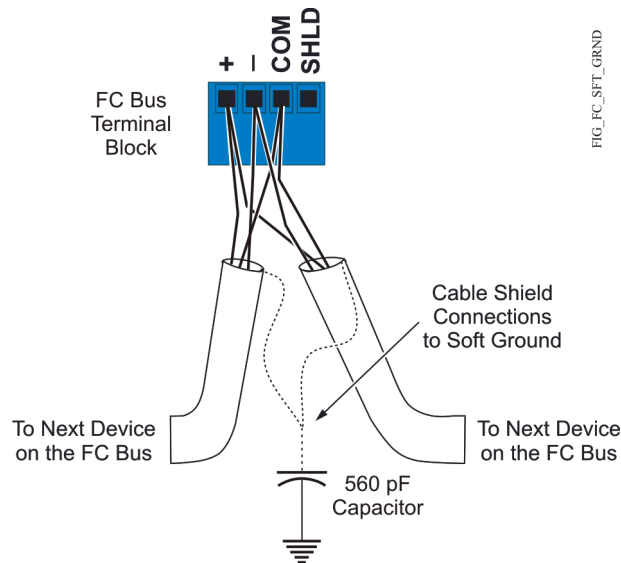
Examples of potential inductive interference include large motors, contactors, relays, welding equipment, high-voltage conductors that are not in metal conduit or raceways, other high wattage devices within 10 m (30 ft) of the bus cable, and areas of frequent lightning.

Examples of potential radio frequency interference include locations near airports, hospitals, radio or television transmission towers, police and fire stations, or factories. Mobile transmitters in police, fire, emergency, and fleet vehicles are also potential sources of radio frequency interference.

Note: The majority of properly grounded MS/TP applications do not require soft ground connections, but you should assess the potential interference that your application may encounter (before you install the bus). It is more efficient to prepare for soft ground connections when making the bus terminations at the initial installation than to return and do it later.

Soft ground connections should be made within 2 inches of the bus terminations of any bus device that experiences frequent offline occurrences resulting from high ambient inductive or RF interference ([Figure 15](#)).

Figure 15: Applying a Soft Ground Connection to an FC Bus



RJ-Style Modular Jack and Cables for SA Bus

The 6-pin modular jack SA bus connection ([Figure 16](#)) is a straight-through (not a crossover) connection and that uses a 6-wire connector cable (with 6-pin RJ-style modular jacks) to connect SA devices to network sensors, DIS1710 Local Controller Display, and the VMA Balancing Sensor. On the 6-wire cable, two wires are used for network communication, two wires for network sensor power, and two wires supply 15 VDC (200 mA maximum) power to the devices connected to the sensor.

The Wireless Commissioning Converter (MS-BTCVT-1) is also connected (temporarily) to the SA bus modular jack to commission the controller.

The cable connected to the SA bus 6-pin modular jack is a straight-through cable and cannot exceed 30 m (100 ft). Do not use crossover cables on the SA bus.

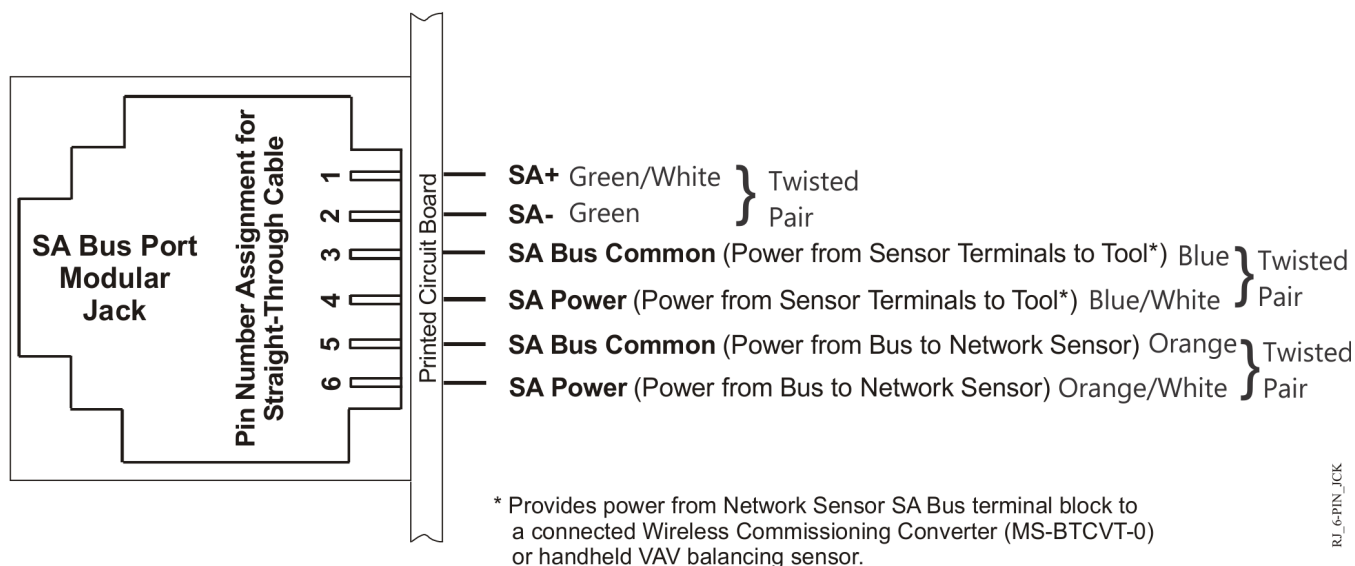
The SA bus 6-pin modular jack supports only one device and no other SA device may be daisy-chained to the port.

Important: Failure to adhere to these wiring details may cause your network sensor to function incorrectly. You are not able to connect to the system using the Wireless Commissioning Converter, the Handheld Variable-Air-Volume (VAV) Balancing Sensor, nor can you expand the system with future offerings.

Every MS/TP device (except the NAE55) has at least one 6-pin modular jack. Modular jacks on the network sensors allow you to connect a Wireless Commissioning Converter (MS-BTCVT-1) or VMA Balancing Sensor. [Figure 16](#) shows the SA Bus modular jack pinout.

Note: Do not mix RJ-style modular (phone) jack and screw terminal devices on the SA bus. Due to the permanent internal SA bus EOL termination contained in FECs, FACs, IOMs, and VMAs, using both the phone jack and terminal block effectively puts the EOL termination in the middle of the SA trunk, creating a star network configuration. This configuration violates the RS-485 network wiring guidelines and can cause unpredictable communication problems.

Figure 16: 6-Pin Modular Jack Pinout Details



RL_6-PIN_JCK

Commissioning Devices on the MS/TP Bus

Commission the devices on the local and remote MS/TP buses using the CCT software. Refer to *CCT Help (LIT-12011147)* for information on commissioning an MS/TP bus application.

Applications and device configurations are downloaded to the hardware from the CCT computer using the Wireless Commissioning Converter or through the NAE, NCE, or Open Data Server (ODS) from the Metasys UI. Refer to the *BACnet® Controller Integration with NAE/NCE Technical Bulletin (LIT-1201531)* for more information.

Hardware points can be auto discovered from the online UI of the NAE, the Application and Data Server (ADS), the Extended Application and Data Server (ADX), or the Open Data Server (ODS).

Peer-to-Peer Communication

Peer-to-peer communication allows non-supervisory engines on a bus to communicate system data with each other directly, bypassing the supervisory engines (NAE/NCE) on the bus.

Appendix: FC Bus Auxiliary Devices

Repeaters

Repeaters are optional components on the FC Bus that increase the maximum allowable length and device counts of the FC Bus. One repeater is counted as one device on the FC Bus. Repeaters are not allowed on the SA Bus.

[Table 13](#) describes how the length and device maximums of the bus change when you add repeaters. The repeater is specified in [Local FC Bus Rules and Specifications](#).

A maximum of two repeaters can be between any two points on the FC Bus.

Note: Some device models and third-party devices may have reduced capabilities.

Table 13: Repeaters on the FC Bus

Maximums ^{1 2}	With No Repeater	With 1 Repeater	With 2 Repeaters
Maximum Segment Length (ft)	5,000	5,000	5,000
Maximum Total Length (ft)	5,000	10,000	15,000
Maximum Device Count Per Segment	50	50	50
Maximum Total Device Count	50	100	100

1 The values in this table represent the recommended 3 conductor, 22 AWG stranded, shielded cable.

2 Some device models and third-party devices may have reduced capabilities.

Configuring Repeaters

The instructions for configuring the repeater for use with the FC bus require that you perform the following:

- Set the baud rate to match the FC bus baud rate.
- Wire the repeater between two segments of the MS/TP bus. If you are using this repeater in a branch, the side with the branch has double the number of wires terminated. See [Figure 17](#).
- Set the EOL jumpers on the repeater according to [Table 14](#).

Note: The EOL jumpers are located below the cover of the repeater.

Note: Sides A and B have separate EOL settings. Determine the settings individually.

For repeater installation instructions and important safety information, refer to the repeater manufacturer's literature.

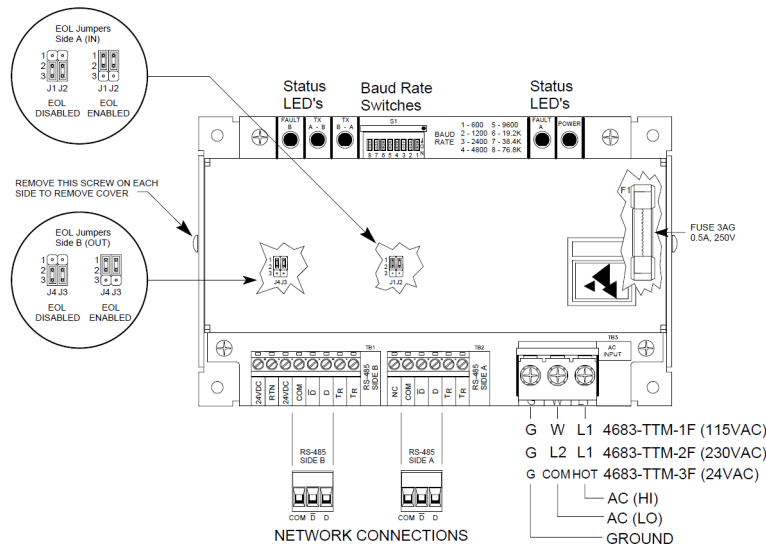


Risk of Electric Shock: Disconnect or isolate all power supplies before making electrical connections. More than one disconnect or isolation may be required to completely de-energize equipment. Contact with components carrying hazardous voltage can cause electric shock and may result in severe personal injury or death.

Table 14: EOL Settings for Repeater

Side	Jumper	Instructions
Side A	J1 and J2	At end-of-line: Install both jumpers over Pins 1 and 2 (EOL In).
		Not at end-of-line: Install both jumpers over Pins 2 and 3 (EOL Out).
Side B	J3 and J4	At end-of-line: Install both jumpers over Pins 1 and 2 (EOL In).
		Not at end-of-line: Install both jumpers over Pins 2 and 3 (EOL Out).

Figure 17: Configuring the Repeater



Fiber-Optic Modems

You can install the 2110 fiber-optic modems in any location on the FC bus. Just as only two repeaters can be cascaded on the FC bus, only two pairs of 2110 modems can be cascaded.

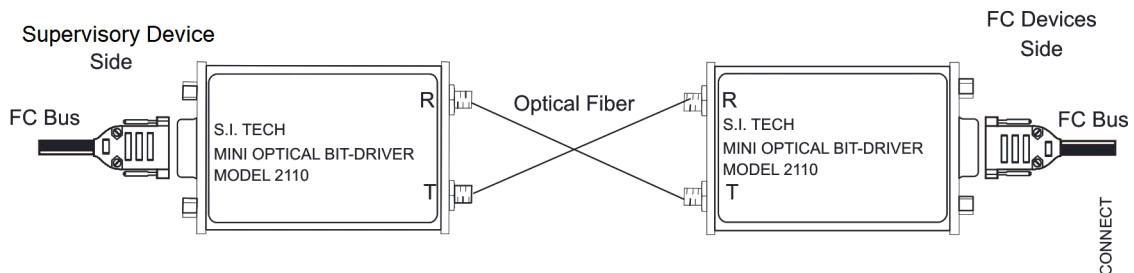
The first installation step is to route the optical fiber and connect each modem to the ends of the fiber. The second step is to connect the FC bus on both sides of the modems.

Routing and Connecting the Fiber Cables

To route and connect the fiber cables, follow these steps and see [Figure 18](#):

1. Route the optical fiber in a manner that is required for the application.
2. Connect the fiber cable from the T (Transmit) output of the modem nearest to the Nx E to the R (Receive) input of the modem near the MS/TP devices.
3. Connect the fiber cable from the T (Transmit) output of the modem near the MS/TP devices to the R (Receive) input on the modem nearest to the Nx E.
4. Plug in the power supply for each modem.

Figure 18: Connecting the 2110 Modems



Connecting Modems to MSTP Bus

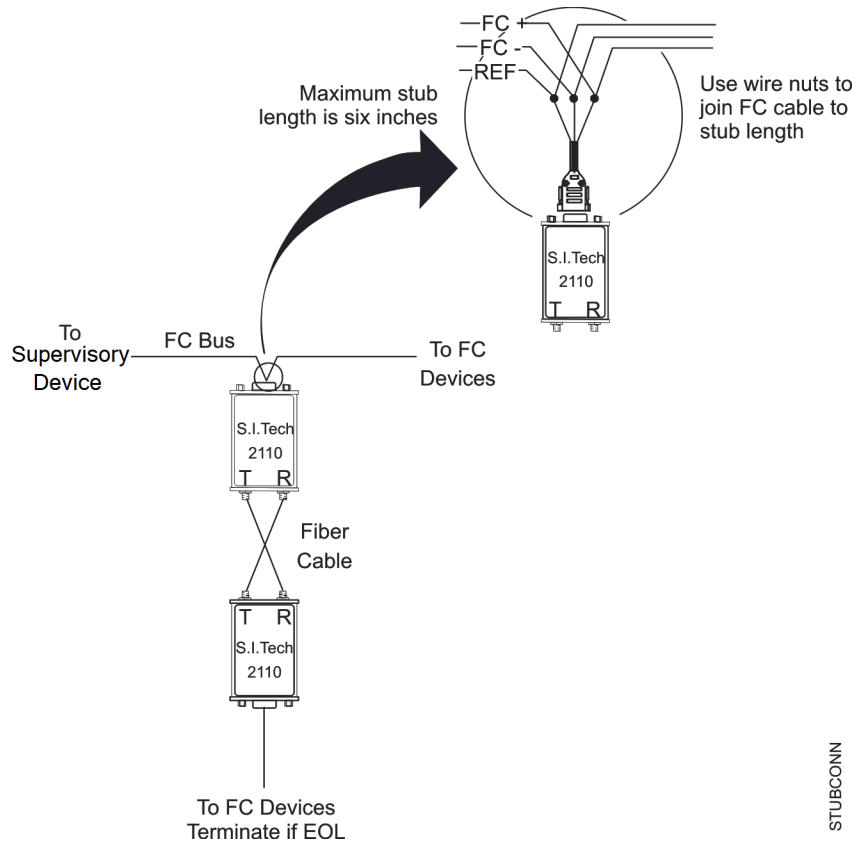
Connect the MS/TP bus to the 2110 modem by soldering the MS/TP wires to pins on the 9-pin connector, which can also configure the modem as an EOL device. To connect the bus, see [Setting Termination on Fiber Modems](#).

Fiber Modem between Two Segments

If you need to place the 2110 modem between two segments of MS/TP bus, wire a stub length of 6 inches or fewer as shown in [Figure 19](#), and terminate the two pairs of MS/TP bus cable at the end of the stub length.

If the fiber modem is at the end of a segment, set the EOL to In.

Figure 19: Connecting 2110 Modem in between Two MS/TP Bus Segments



Setting Termination on Fiber Modems

The 2110 modem does not have an EOL jumper. Instead, establish EOL termination on a 2110 modem by properly terminating the FC bus wires to the 9-pin connector. Soldering the wires to specific pins and soldering two jumper wires configures the modem as an end-of-line device (see [Figure 20](#), [Figure 21](#), and [Table 15](#) for more information).

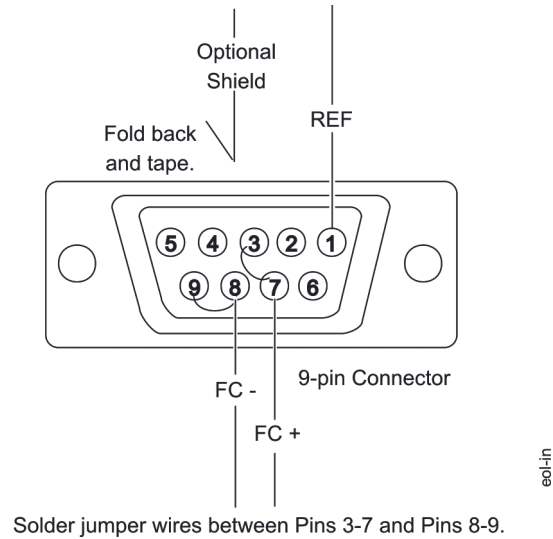
Do not set the fiber modem as an EOL device on the SA bus.

Modem Set EOL to In

To set the modem as an end-of-line device, wire the 9-pin connector using solder connections as shown in [Figure 20](#).

Note: The following figure shows the 9-pin female connector. The pin numbers on the 9-pin male connector are reversed.

Figure 20: Female Modem Cable Connector: EOL Set to In



Modem Set EOL to Out

To set the modem with the end-of-line selection set to Out, wire the 9-pin connector using solder connections as in [Figure 21](#).

Note: The following figure shows the 9-pin female connector. The pin numbers on the 9-pin male connector are reversed.

Figure 21: Female Modem Cable Connector: EOL Set to Out

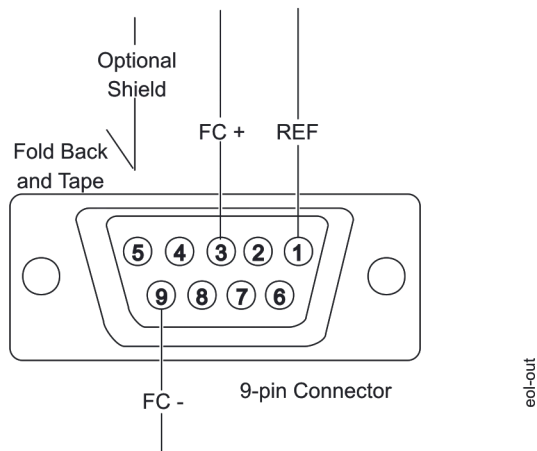


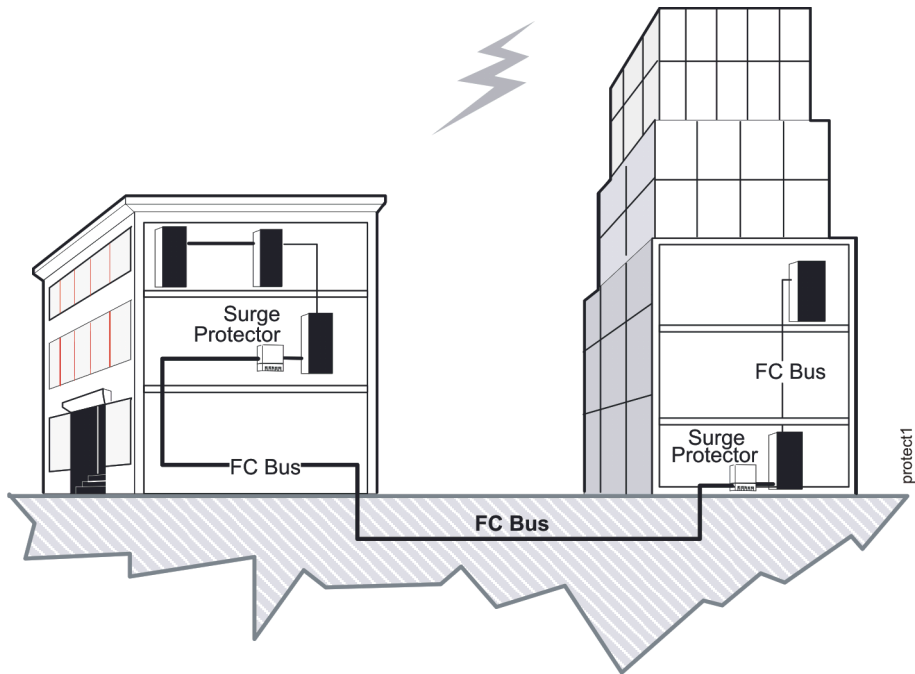
Table 15: EOL Connections Summarized

FC Bus Signal	For EOL Selection	For Non-EOL Selection
FC +	Terminal 7, Jumper 7-3	Terminal 3
FC -	Terminal 8, Jumper 8-9	Terminal 9
REF	Terminal 1 or 5	Terminal 1 or 5
SHIELD	Tape Back	Tape Back

Surge Protectors

Surge protection is strongly recommended if the MS/TP bus is wired between buildings. The protection is provided by a voltage surge suppressor, which is installed on the MS/TP bus near the MS/TP device. Example applications are shown in [Figure 22](#).

Figure 22: Surge Protector Installation on MS/TP Bus



Note: Fiber-optic bus connections between buildings are immune to transient voltage and other problems associated with hard-wire bus connections. Fiber-optic bus connections do not require surge protection and may be less costly to install. See [Fiber-Optic Modems](#) for information.

The recommended surge protector is the Transient Eliminator, model TE/JC04C12, manufactured by Advanced Protection Technologies, Inc. (APT). The device protects the MS/TP bus from indirect lightning, and shunts both common and normal mode voltage surges to ground repeatedly without damage to MS/TP bus components.

Important: The surge protector is capable of protecting the MS/TP bus from indirect lightning strikes, not direct lightning strikes. A direct strike may cause actual damage to the bus cable or surrounding property. An indirect lightning strike may cause induced voltage transients that could cause electronic malfunction without visible damage to equipment if the equipment were not protected.

Use the surge protector with the standard MS/TP bus wiring. Do not use it with any other type wiring such as leased line. If you need surge protection for other wire types, contact APT or another transient noise protection company.

[Table 16](#) lists the specifications of the surge protector.

Table 16: Surge Protector Specifications

Category	Specification
Product Name	Transient Eliminator
Generic Name	Surge Protector
Model Number	TE/JC04C12
Design	Three stage solid-state design using both metal oxide varistors and silicon avalanche diodes for suppression
Response Time	Less than 1 nanosecond
Maximum Impulse Current (8/20 ms current impulse)	10 kA per conductor

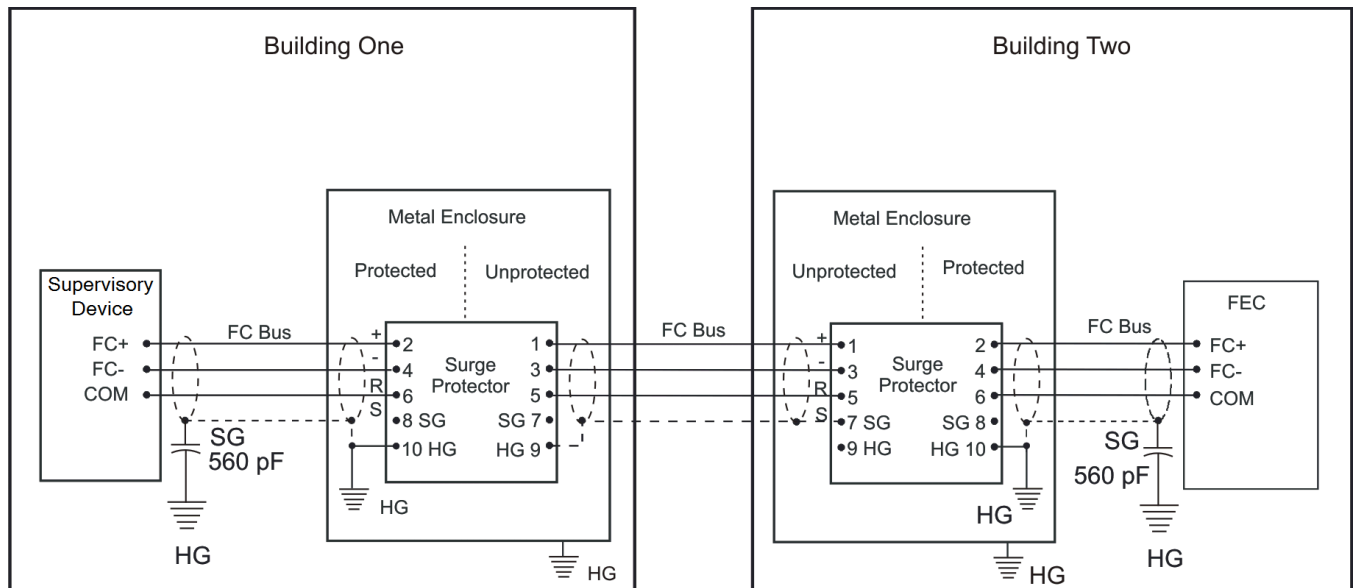
Table 16: Surge Protector Specifications

Category	Specification
Maximum Energy Dissipation	80 Joules per conductor (10/1000 us)
Maximum Operating Voltage	12 VDC
Protection	Common and normal modes
Suppression Voltage Levels (Common mode)	100 kHz ringwave at 200 A: 15.8 volts 100 kHz ringwave at 500 A: 16.8 volts 3 kA combination wave: 20.8 volts
Maximum Number of Protectors Allowed on MS/TP Bus	One pair per bus segment
Maximum Length of MS/TP Bus Between Two Buildings Using Protector	1,524 m (5,000 ft) (standard MS/TP bus specification)
Other Mechanical Features	Encapsulated in Ceramgard® composition for insulation and environmental protection. Two-part design for easy connection and replacement of protective device to base using edge connector. Durable UL Recognized plastic enclosure material
Dimensions (H x W x D)	63.5 x 50.8 x 25.4 mm (2.5 x 2.0 x 1.0 in.)

One pair of surge protectors is required whenever the MS/TP bus wire is routed outside between two buildings. APT recommends that you install the protector close to the MS/TP device that first receives the bus wires from the outside. [Figure 23](#) shows an FC bus surge protector wiring example.

The protector does not require that you use any special type of wire for the MS/TP bus, such as double-shielded twisted cable. Use the standard recommended twisted cable types.

Figure 23: FC Bus Surge Protector Wiring Example



Notes:

Hard Ground (HG) bus shielding connections should be at a single location in each bus segment. Introducing multiple hard ground points of bus shielding in a single bus segment may result in large circulating ground currents in the shield.

For the surge protector's hard ground, use 12 AWG stranded wire, 4.57 m (15 ft) maximum length, connected to Pin 9 or 10 (pins 9 and 10 are internally connected on the surge protector).

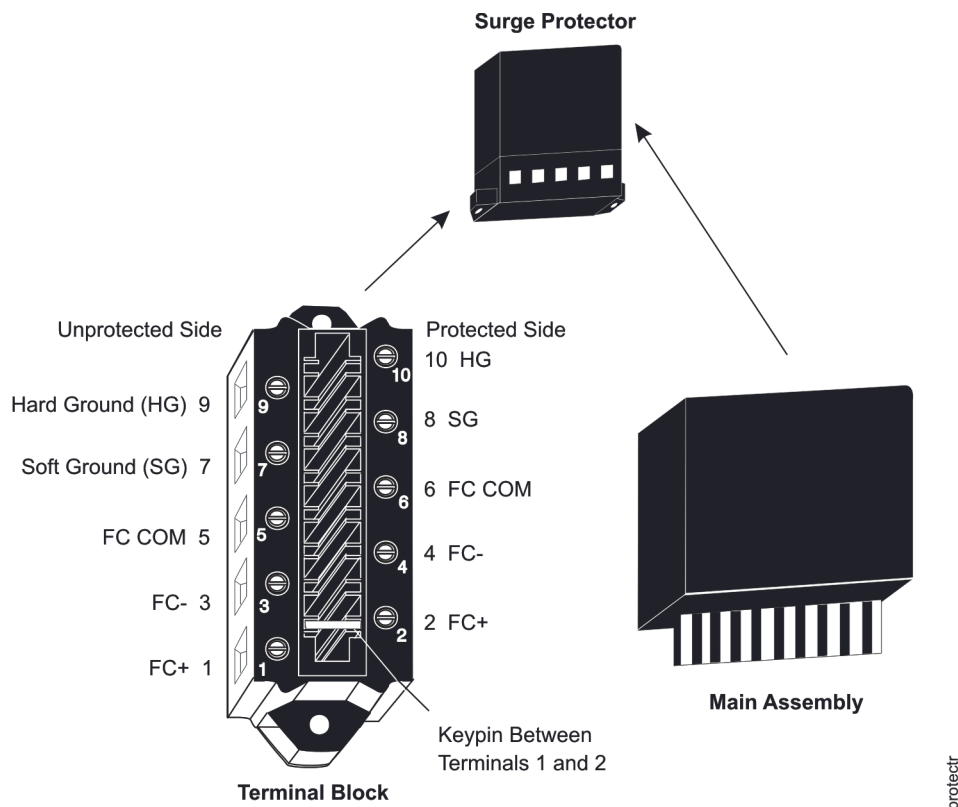
Make sure wires entering the surge protector's enclosure are not close to the wires leaving the enclosure.

Soft Ground (SG) the Bus shield at all other controllers wired to the FC Bus.

FC_Bus_Surge

The surge protector consists of two sections: the terminal block and the main assembly. These sections separate to make the unit easier to install and replace ([Figure 24](#)).

Figure 24: Sections of Surge Protector



The surge protector is wired depending on which device requires protection. Follow these general steps:

1. Mount the Transient Eliminator device per local codes. Install in an enclosure (if required) as close as possible to the first MS/TP device connecting the trunk segment entering the building. Any electrical box with a cover is acceptable. Bond the transient eliminator enclosure to the MS/TP device enclosure by connecting the two with the conduit that carries the MS/TP cable.
2. Connect the MS/TP segment from the outside to the unprotected side of the device. If possible, run the segment inside metallic conduit because the conduit acts like a shield for lightning.
3. Connect the MS/TP segment that goes to the MS/TP device to the protected side of the device. Keep this segment away from the unprotected segment.
4. Connect the protector to earth ground with 12 AWG stranded green wire ([Figure 23](#)). The total length of ground wire cannot exceed 4.57 m (15 ft), which means an earth ground must be available within 4.57 m (15 ft) of the MS/TP device. (Your installation design must accommodate this requirement.)
5. For hard ground installation, connect the shield to Pin 9. For soft ground installation, connect the shield to Pin 7.

For more details on installation, refer to the specific manufacturer's literature.

Appendix: Maximizing and Troubleshooting the MS/TP Bus

Maximizing Tips

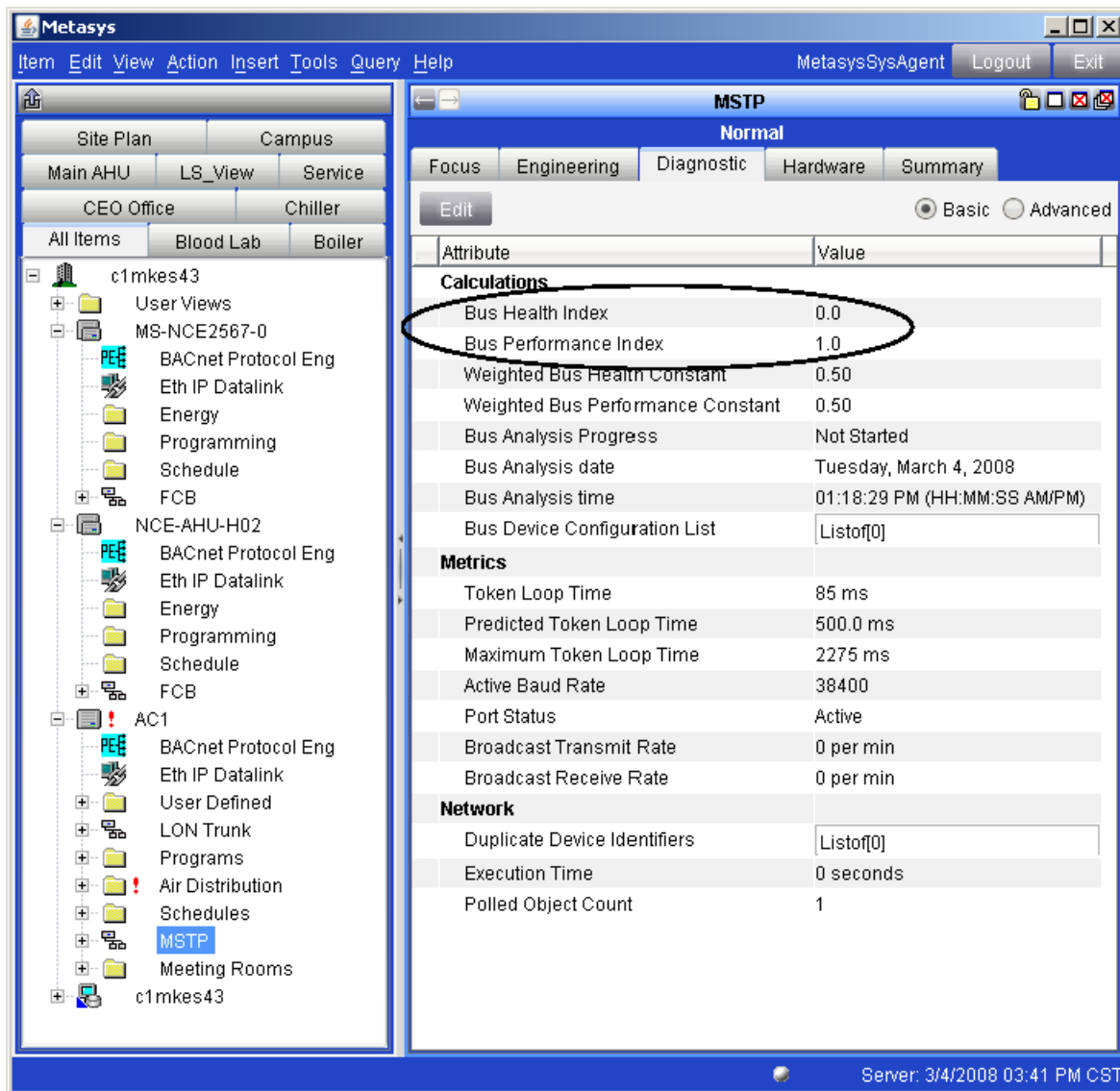
Observe the following guidelines to maximize the performance of an MS/TP bus.

Guideline	Description
Limit the Number of Change of Value (COV) Report Rates over the MS/TP Bus	<p>COV reports account for the highest amount of traffic on the bus. For best performance, keep the COV rate at 500 COVs per minute or fewer for each network. To reduce the COV traffic:</p> <ul style="list-style-type: none">• Set the COV increment to the largest value that still provides acceptable performance.• Do not map more points to the NxE than are required. <p>For mapped analog points, where the values are changing frequently, consider the following to limit COV reports:</p> <ul style="list-style-type: none">• Increase the COV increment on the point. <p>Note: For some Analog Inputs (AIs), this value cannot be modified.</p> <ul style="list-style-type: none">• Set the Use Cov Min Send Time flag to true, which causes the COVs to be sent on a timed basis. The time value is specified in the controller device object.
Do Not Place Slave Devices on the FC Bus	Slave devices on the FC bus are not supported. The SA bus only supports a specific set of slave devices.
Carefully Evaluate Third-Party Devices	Third-party devices can seriously degrade both hardware and software performance depending on their quality and configuration. Consider and configure third-party devices carefully according to the manufacturer's specifications.
Do Not Add Extra Traffic	Once the system is configured, commissioned, and running, avoid adding extra traffic to the bus by performing unnecessary auto-discovery operations, downloads, or bus analysis.
Observe the MS/TP Wiring Guidelines	Follow the wiring rules carefully. The tolerances of the MS/TP bus are tighter than other, slower protocols may be. Improper terminations may result in errors causing serious network degradation. See MS/TP Bus Cable Recommendations .
Check the MS/TP Statistics for Errors	See Statistics Attributes .
Use Default MS/TP Settings	Avoid changing default MS/TP bus settings, especially settings you may be unfamiliar with. Some parameters set improperly or randomly can cripple the MS/TP bus completely.

MS/TP Bus Health Factors of the Diagnostics Tab

The Diagnostics tab of the MS/TP field bus integration, viewed from the Metasys system UI, provides a snapshot of the condition of the bus. The attributes that are most illustrative of the bus condition are the Bus Health Index and Bus Performance Index attributes, both located under Calculations ([Figure 25](#)). The Statistics attributes also provide a useful look into the condition of the MS/TP bus.

Figure 25: MS/TP Object Diagnostic Tab



Bus Health Index

The Bus Health Index is a snapshot of the immediate number of errors on the bus. This index provides a weighted moving average of four MS/TP bus error counters: **Framing Errors**, **Header CRC Errors**, **Data CRC Errors**, and **Lost Tokens**. The ideal value for the Bus Health Index is zero.

Because the average is reevaluated every 30 seconds, the average gradually returns to zero if no new errors occur. As such, if errors occur only periodically (for example, only when a source of bus interference [such as a welder] is in use), the Bus Health Index may return to zero before you see the value indicate that there are errors. If you suspect that errors are occurring, look at the four error counter attributes. Alternatively, you can trend the Bus Health Index to see when or if it changes during the course of the day.

The **Weighted Bus Health Constant** attribute is an adjustment factor that determines how quickly the Bus Health Index returns to zero if there are no new errors. The smaller the value of the constant, the slower the index returns to zero.

Typically, the errors indicated by the Bus Health Index are physical bus problems. See [Correcting Physical Bus Problems](#).

Bus Performance Index

The Bus Performance Index provides a snapshot of the performance of the network by taking the weighted moving average of the ratio of the actual loop time to the predicted loop time.

The **Weighted Bus Performance Constant** attribute is an adjustment factor that determines how quickly the index changes when the actual loop time changes.

Because a master device is allowed to originate messages only when it holds the token, the token loop time is closely related to network performance. During normal operation, the token loop time should not exceed 2 seconds (2,000 milliseconds). Special Operations (such as Auto Discovery, device downloads, or bus analysis) may cause the loop time to exceed this value temporarily, but this is no cause for concern; unless, the token loop time continually exceeds 2 seconds, then the bus may be experiencing excessive errors or data overload. The 2-second loop time figure is the upper limit of an ideal token loop time; however, the Bus Performance Index predicts what the token loop time should be, based on the number of devices, the baud rate, and the number of messages.

The ideal value for the Bus Performance Index is 1. [Table 17](#) provides the guidelines of the Bus Performance Index.

Table 17: Bus Performance Index

Index Value	Description
1.0 - 1.9	Best performance, no performance problems
2.0 - 2.9	Acceptable performance
3.0 - 5.9	Possible slower performance, bus may be overloaded
6.0 or Greater	Poor performance, devices going offline, other problems

High numbers (around 6 and higher) can indicate a physical problem or that the bus communication is overloaded. If the Bus Health Index is zero, the problem is probably due to an overloaded bus. See [Correcting Bus Overload Problems](#).

Statistics Attributes

The Statistics attributes of the MS/TP Field Bus Integration object Diagnostics tab (Advanced View) provide useful information about what is happening on the MS/TP bus. [Table 18](#) describes some of the attributes and values that indicate there is a problem on the bus. For more details on the following attributes, refer to the MS/TP Field Bus Integration Attributes section of the Metasys system *Help* (LIT-1201793).

Send the **Latch Statistics** command to the MS/TP field bus integration before comparing your values to [Table 18](#). If the statistics have already been latched and represent old data, send the **Clear Statistics** command. Wait a minute or longer for new data to accumulate and send the **Latch Statistics** command.

For more information on statistics, refer to the Metasys system *Help* (LIT-1201793).

Table 18: Statistics Attributes

Attribute	Error Condition Indicated
Unexpected Frames Rxed	Possible network disruption
Packets Timed Out	Noise, bad wiring, or another device did not respond.
Framing Errors	Noise, bad wiring, or mismatched baud rates
Overrun Errors	This node is too busy.
Header CRC Errors	Noise or bad wiring
Data CRC Errors	Noise or bad wiring
Reply Too Slow Datalink Errors	Another device is slow to respond.
Reply Too Slow Application Errors	The node is too busy to build the reply at this time.
Internal Errors	Low memory or unexpected conditions

Table 18: Statistics Attributes

Attribute	Error Condition Indicated
Buffer Overflows	The node is trying to send or receive too much at this time.
Lost Token	Network disruption (includes initial startup, so 1 is common)
Retries	Problems passing the token message

Analyze Field Bus Command

The Analyze Field Bus command provides detailed information about the devices that currently reside on the local or remote MS/TP bus. The command tells the NAE to poll each address on the FC bus, in order from 1 to 254. The polling takes several minutes to complete. Once it finishes, the Bus Analysis Progress attribute reads Complete and the Bus Device Configuration List displays each device on the bus.

Note: To use the Analyze Field Bus command on a Remote Field Bus, at least one of the MS/TP field controllers must be an FEC family Metasys device.

This command attempts to show the address, make, and other attributes of each device on the bus. You can use this information to identify devices you are unaware of and to identify third-party devices on the bus. The results of the scan can vary depending on the device type and manufacturer of the devices on the bus.

To issue the Analyze Field Bus command:

1. Right-click the MS/TP Field Bus Integration object in the navigation tree and select **Commands** from the pop-up menu. The Select Command dialog box appears.
2. Select **Analyze Field Bus** and click Send. The **Bus Analysis Progress** attribute value changes to **In Progress**.
3. After the **Bus Analysis Progress** changes to **Complete**, read the devices from the **Bus Device Configuration List** drop-down menu (Figure 26) using Table 19.

Figure 26: Bus Device Configuration List Example

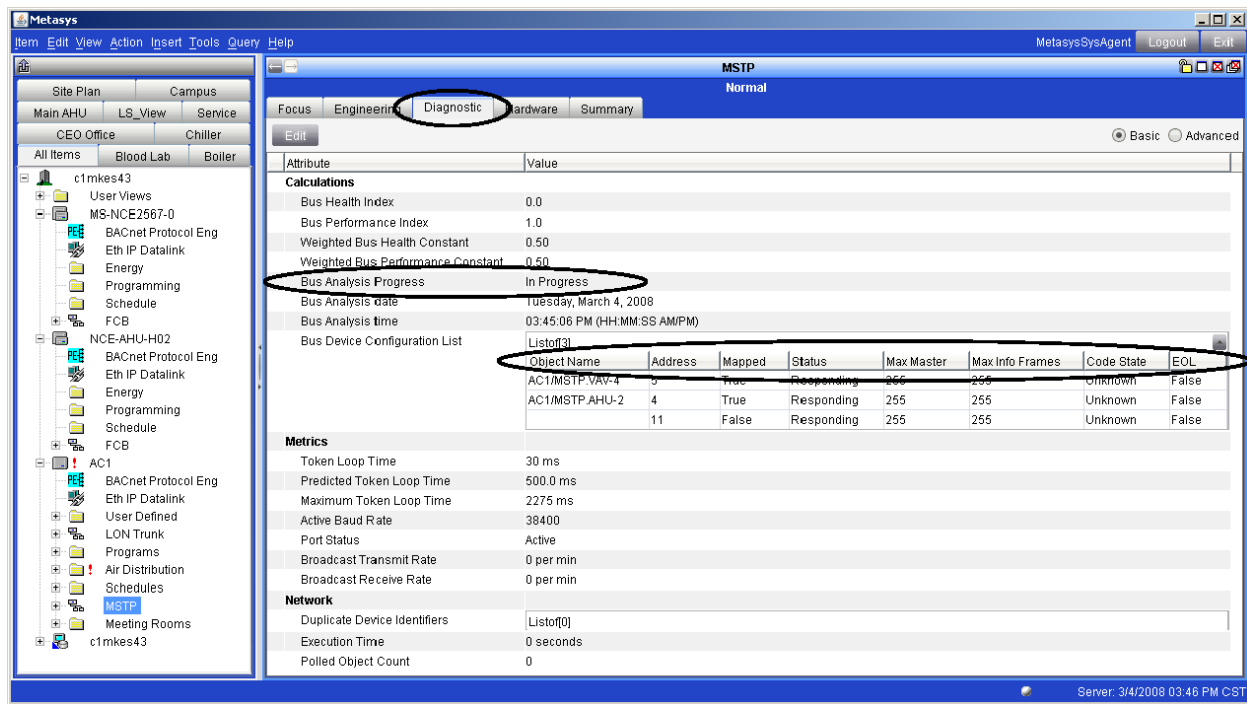


Table 19: Bus Device Configuration List

Label	Description	Possible Values/Exception Values
Object Name	Displays the name of the field device. The name is derived from following in this order: 1. If the field device appears in the navigation tree, the name on the tree is used initially. 2. If the device is communicating on the field bus, its name is read directly and overwrites the current name. 3. If the device does not appear on the navigation tree and it is communicating, but its name cannot be read, the field is left blank.	Any name or number
Address	Displays the MS/TP address of a device if the device appears in the navigation tree or the device responds to the analyze field bus command poll.	1 - 255
Mapped	Indicates whether devices are mapped to the Metasys system.	True indicates that the device is mapped and appears on the navigation tree. False indicates that the device is not mapped and does not appear on the navigation tree. Note: Currently, the Device Mapped label only applies to the FEC, FAC, IOM, and VMA16 Series controllers. Other devices may return a False value even though they are mapped and appear on the navigation tree.
Status	Indicates whether the device responded to the analyze bus poll.	Responding indicates that the device responded to the poll. No Response indicates that the device appears in the navigation tree but did not respond to the poll.
Max Master	Displays the Max Master attribute of the device. If the device is configured, the default value is 127. If the attribute cannot be read, the value displayed is 255.	<127 indicates that the Max Master attribute has been altered. See Parameters That Affect MSTP Communication . 127 is the default value and indicates that the device is configured. 255 indicates that the poll could not read the Max Master attribute.
Max Info Frames	Displays the Max Info Frames attribute of the device. If the device is configured, the default value is 10. If the attribute cannot be read, the value displayed is 255.	10 is the default value and indicates that the device is configured. 255 indicates that the poll could not read the Max Info Frames attribute.

Table 19: Bus Device Configuration List

Label	Description	Possible Values/Exception Values
Code State	Indicates the state of the operating code within Johnson Controls® field devices. This field is meaningful only for Johnson Controls field devices.	<p>Boot indicates that the device is starting and is not completely functional.</p> <p>Main indicates that the device is functional and operating.</p> <p>Unknown indicates that the device is not responding or does not support the Code State attribute.</p>
EOL	Displays the end-of-line termination status of a Metasys an FEC, FAC, IOM, and VMA16 (only).	<p>True indicates the FEC, FAC, IOM, and VMA16 EOL switch is On.</p> <p>False indicates the FEC, FAC, IOM, and VMA16 EOL switch is Off.</p> <p>Note: All other devices on the bus display False regardless of the status of their EOL status.</p>

Parameters That Affect MSTP Communication

The following parameters can be adjusted to tune MS/TP communication.

Important: Do **not** adjust attributes with which you are unfamiliar. If set improperly, the following parameters can adversely affect MS/TP communication.

The **Baud Rate Selection** attribute specifies the baud rate. If the baud rate is forced to be different from other devices on the bus, communication ceases. To change the baud rate, see [Changing the Baud Rate of an Entire Bus](#).

The **Max Master** attribute specifies the highest address that can be a master on the bus. By adjusting this value, you can prevent some devices from coming online as bus masters. All devices on the bus must have the same Max Master attribute value to prevent the token from going to a device with an address above the Max Master attribute value.

The **Max Application Protocol Data Unit (APDU) Length Accepted** attribute specifies the largest data packet that is allowed on the bus. **If set improperly, this parameter can cripple the bus.**

The **APDU Timeout** attribute determines how long the NAE waits for an acknowledgement from a device when the message can be sent in one transmission. If set too low, many messages fail. If set too high, error recovery is delayed. You can change this value in special situations when dealing with third-party devices or overloaded networks.

The **APDU Segment Timeout** attribute determines how long the NAE waits for an acknowledgement from a device when the message is sent in multiple segments. If set too low, many segmented messages fail. If set too high, error recovery is delayed. You can change this value in special situations when dealing with third-party devices or overloaded networks.

The **APDU Retries** attribute determines how many retries are allowed when trying to recover from an error. If changed improperly, the network may slow down or become more sensitive to noise. You can change this value in special situations when dealing with third-party devices or overloaded networks.

Duplicate Addresses

Two or more devices on a bus cannot have the same address. If two devices on the same bus have the same address, performance can degrade or serious communication problems can occur, including devices not coming online and the cessation of all communications on the bus.

Check for duplicate addresses in the following ways, depending on the severity of the situation:

- If bus performance is degraded, check the address switch settings at the devices with unreliable communications.
- If the bus communications problems are severe, and there is no communication or you cannot determine where communication is unreliable, partition (disconnect and isolate a portion of the bus for testing purposes) and test the bus portion connected to the NAE (or Wireless Commissioning Converter [MS-BTCVT-1]).

Common Problems

Several factors can influence the behavior of the MS/TP bus. In addition, certain problems can affect the bus in multiple ways and have more than one symptom, making the exact diagnosis difficult. For example, duplicate addresses on the bus can degrade performance, make a device go offline, or stop communication completely. [Table 20](#) lists common problems that you should consider when troubleshooting an MS/TP bus. The first row, **Multiple Symptoms**, lists possible problem causes that can have multiple symptoms.

Table 20: Common Problems

Symptom	Possible Causes
Multiple Symptoms	<ul style="list-style-type: none"> • Excessive bus errors are occurring. • A device was added or changed with a duplicate address (may not be the same address as some devices having problems, and may have happened some time before the problem was noticed). • Wiring errors or wire problems exist. • The baud rate was changed on some devices on the network, but not all devices. • Max Master was changed incorrectly (this may have happened some time before the problem was noticed). • A download is in progress. • There is a fault at a device. • A repeater is needed or configured incorrectly. • There is a duplicated Device Object name or instance. • The EOL termination is improperly set. • The BACnet Router used with a Remote Field Bus is defective or has poor performance. • The same Network Number is being used on the MS/TP side of more than one BACnet Router, NAE, or third-party gateway at the site.
Poor Performance	<ul style="list-style-type: none"> • Excessive bus traffic exists (bus overload). • Baud rate may be set too low. • Too many devices may exist on the network. • Unaccounted devices are on the network (that is, not mapped to the NAE). • Unusually slow devices are on the network or devices that are slow to pass the token. • Multiple integrations (Remote Field Bus integration or BACnet integration) are using the same BACnet Router. • More than one supervisory device is using the same BACnet Router.

Table 20: Common Problems

Symptom	Possible Causes
Devices Go Offline	<ul style="list-style-type: none"> • Device is failing to respond to the NAE's request. • Power or other failure occurred at the device. • Communication is disabled at the device. • Multiple integrations (Remote Field Bus integration or BACnet integration) are using the same BACnet Router. • More than one supervisory device is using the same BACnet Router.
Device Does Not Come Online	<ul style="list-style-type: none"> • The device may be connected to the wrong bus. • The baud rate of a new device is incompatible with the baud rate of the running network. • No device on the network is configured to use a specific baud rate (normally the NAE), but all devices are set to use auto baud. At least one device, typically the bus supervisor (NAE), must have an assigned baud rate. Set the baud rate in the bus supervisor and set all other devices to Auto baud. • Device failed to download Main Code. • The BACnet Router needs a BBMD defined or the BBMD is defined incorrectly. • The same Network Number is being used on the MS/TP side of more than one BACnet Router at the site. • A BACnet Router has failed or locked up. This problem may occur if you use a router that is not tested nor recommended. • Duplicate addresses exist

Correcting Physical Bus Problems

The MS/TP bus is subject to a number of physical factors that can affect performance. Consider the following common physical attributes:

- Check wires.
 - Verify proper wire gauge, connections, polarity, and lengths.
 - Look for opens and shorts.
- Check terminations.
 - Verify that EOL terminations are only at the ends of daisy chains.
- Check addresses.
 - Check for duplicate addresses.
 - Verify that the address range is sequential.
- Check for and eliminate T-Taps (wire configurations that create a T shape) and star configurations.
- Check for consistent baud rates.
- Check for sources of interference.

Correcting Bus Overload Problems

Excessive data communication on the MS/TP bus can degrade system performance. To reduce the load on the bus, consider the following:

- Unmap points you do not need.
- Minimize the number of COVs on the bus; see [Counting the COVs](#).
 - Check and increase the COV increment for noncritical points.
 - Use a timed COV interval for fast changing points. Set the **Use COV Min Send Time** attribute to True.
 - Lengthen the COV timed interval **COV Min Send Time 10-255** in the device object. The default is 15 seconds.

- Check for and correct unstable sensors.
- Reduce the number of devices on the bus, if possible.
- If running at less than 38.4k baud, increase the baud rate (if possible).
- Verify repeaters, if applicable.
 - Verify that repeaters are used where needed.
 - Verify that repeaters are configured and wired correctly.
 - Verify that BACnet Routers are associated with a single integration (Remote Field Bus) at a single supervisory device.

Reading the Baud Rate of Devices

Attributes in the Metasys system UI display the baud rate settings and current baud rates of devices on the bus.

[Figure 27](#) shows an example of the baud rate attributes in the NCE.

If the NAE is connected to an MS/TP bus that is already communicating at an unknown baud rate, you can temporarily set the NAE Field Bus Integration object Baud Rate Selection to Auto. You can then read the current baud rate from the Active Baud Rate attribute in the NAE.

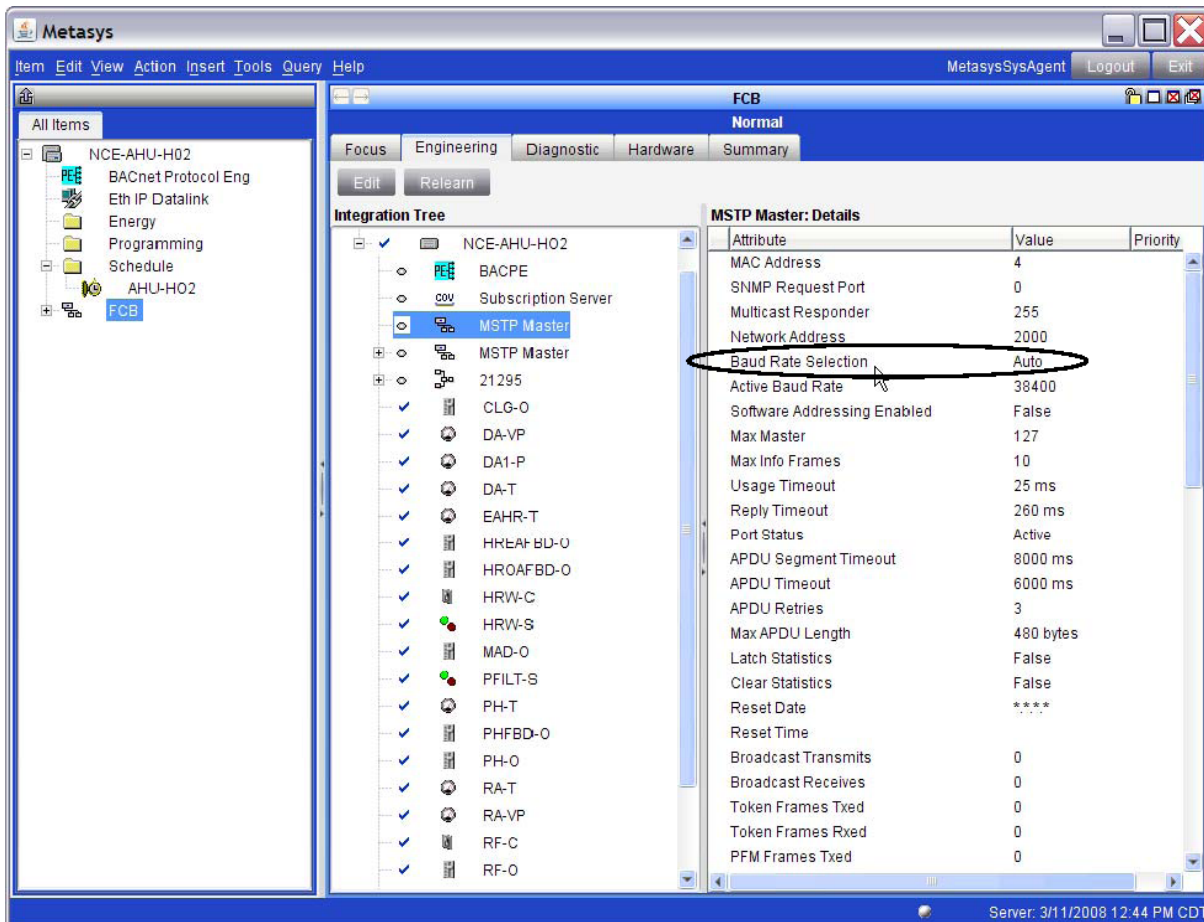
To read the baud rates of devices, see [Table 21](#).

Table 21: Reading Baud Rates in the Metasys SMP User Interface

Device	To Read the Baud Rate Setting and the Current Baud Rate
NAE	<ol style="list-style-type: none"> 1. In the Metasys SMP UI, display the Field Bus integration. 2. Select the Hardware tab, Baud Rate Selection indicates the baud rate selection specified for the NAE. 3. On the Diagnostics tab, Active Baud Rate displays the current baud rate of the bus.¹
Field Device on the FC Bus ²	<ol style="list-style-type: none"> 1. In the Metasys system UI, access the Field Bus integration. 2. On the Engineering Tab, expand the field device object. Double-click the desired MS/TP bus object. 3. Baud Rate Selection indicates the baud rate selection specified for the field device. <p>Active Baud Rate displays the current baud rate of the bus.¹</p>

- 1 This attribute displays the baud rate at which the device is currently communicating. If the device Baud Rate Selection is set to Auto, you can use this attribute to see what the baud rate actually is.
- 2 This applies to Johnson Controls field controllers. Metasys system TEC Series thermostats and third-party devices may have different means of reporting the baud rate.

Figure 27: MSTP Master Summary Showing Baud Rates



Counting the COVs

You can check the COV report rates on the main device object Diagnostics tab of each device that supports this measurement. The two attributes are **COV Tx Rate** and **COV Rcv Rate**. The NAE COV Rcv Rate is the total for all connected networks including the Ethernet and should not exceed 500 per minute. The COV Tx Rate counts only the reports originated by this device. Double clicking on the Trunk object at the top of the tree on the engineering tab displays a list of devices, and the COVs TX, from devices that report this information. For more information on these attributes, refer to the *NAE Object* and the *MS/TP Field Device Object* in the Metasys system *Help*.

Disabling a Device on the Bus

If a device is causing communication problems, the **Disable** command from the Metasys system UI allows you to take the device offline. Once disabled, the device no longer sends or receives data, but remains in the token loop to maintain bus integrity and pass the token to the next device.

This procedure only prevents data related problems and has no effect on addressing or token loop problems.

Note: This command works on specific devices; it is not available on TEC Thermostat Controllers and may not be available on third-party devices.

To disable a device on the bus:

1. On the navigation tree, right-click the device you want to disable and select **Commands** from the pop-up menu. A dialog box appears for the device.
2. Select **Disable** and click **Send**. The device goes offline and a red X appears in front of the device in the navigation tree.

The device remains offline until you repeat this procedure and send the **Enable** command.

Changing the Baud Rate of an Entire Bus

The following procedure represents recovery steps to synchronize the baud rate on the MS/TP bus. You may need to perform this procedure if:

- the baud rate of the bus supervisor (typically, the NAE) does not match that of the bus
- you need to change the baud rate of the bus
- you connect two buses operating at different baud rates

In general, we recommend that you set the bus supervisor (NAE) to 38,400 baud and set all of the other devices on the bus to Auto.

Note: To change the baud rate of the bus, you need a Wireless Commissioning Converter (MS-BTCVT-1), and you need access to the Metasys system UI and the laptop where CCT and the Wireless Utility are installed.

Note: A TEC Thermostat Controller must not be the lowest numbered address on the bus.

To change the baud rate of a bus:

1. Connect the Wireless Commissioning Converter (MS-BTCVT-1) **directly to the bus you want to change**.

Important: This procedure disrupts bus communication until completed. Be sure you have connected the Wireless Commissioning Converter to the correct bus before proceeding.

2. Start the Wireless Utility. (Refer to the *Metasys CCT Bluetooth Technology Communication Commissioning Guide [LIT-12011038]* for more information on the Wireless Utility.)
3. In the Metasys system UI, change all of the devices whose baud rate is manually specified (that is, not set to Auto) to the new baud rate.

Note: Change the baud rate of the bus supervisor last.

4. Change the baud rate of all bus repeaters, bus modems, and third-party devices to the new baud rate.

Note: Devices may appear to go offline as you change baud rates.

5. In the Wireless Utility, specify the new **Baud Rate**, select **Force New Baud Rate**, and click **Change**. This process takes approximately 3 minutes.

Note: TEC Thermostat Controllers do not assume the new baud rate for 10 minutes.

6. Once the Force New Baud Rate process is complete, access the Metasys system UI and verify the baud rate from the UI and that all devices came online.

Note: If the old baud rate is still the active baud rate, a device on the bus may still be manually set to use the old baud rate.

Automatic Low Resources Monitoring

Resources such as available memory and internal queues are continually monitored by the BACnet® communications software including the IP communications and MS/TP components of the controllers. If any resource becomes overloaded, the BACnet communications software reduces the throughput (throttles it back) to allow the controller a chance to recover.

Exceeded resources are classified into degrees of severity as follows:

- **Warning** means the resource is in short supply.
- **Trouble** means the resource may cause some observable problems.
- **Alarm** means the resource is causing observable problems.
- **Critical** means the resource is almost exhausted and operation may fail.

In some cases, there are statistical counters that count when recovery actions have been taken. The following sections define four resources monitored by the BACnet software and describe what you may notice if the resource throughput is reduced.

The Object Engine Input Queue

The Object Engine Input Queue handles all incoming messages intended for object level operations. The Object Engine processes these messages in order by priority, one at a time. If this queue is backing up, operation is slow and applications sending messages may encounter errors.

If the Object Engine Queue is overloaded, you may notice the following:

The BACnet® protocol messages (starting with the lowest priority) received by the queue are aborted (discarded if in the Alarm or Critical state). The Protocol Engine counter, **Rcv Messages Discarded** (under BACnet Protocol Eng, Diagnostic tab), counts and displays the number of discarded messages.

If the Object Engine Queue is critical, all messages sent to the queue (including internal messages) receive an error and BACnet protocol messages received from the IP port are discarded. **Discarded Frames** (under Eth IP Datalink, Diagnostic tab) counts and displays the number of discarded messages.

Available Free Memory

Free memory is required to buffer all incoming and outgoing messages, as well as to save information needed for internal processing. If available free memory becomes low, some communications fail and devices may drop offline. If available free memory becomes completely depleted, all processing fails.

If the free memory available is low, received BACnet® protocol messages (starting with the lowest priority) are aborted (discarded if in the Alarm or Critical state). The Protocol Engine counter, **Rcv Messages Discarded** (under BACnet Protocol Eng, Diagnostic tab), displays the number of discarded messages. Additionally, BACnet protocol messages waiting to be transmitted are also discarded. If an external node is waiting for a reply, an abort is sent unless the condition is alarm or critical. The number of aborted messages are counted and displayed in **Abort Tx** (under BACnet Protocol Eng, Diagnostic tab). The Protocol Engine counter, **Tx Messages Discarded** (under BACnet Protocol Eng, Diagnostic tab), displays the number of discarded messages. If this state exists for more than a few seconds, external BACnet protocol devices may be flagged offline.

If the free memory available is at the alarm level or worse, checking for the online/offline status of external BACnet protocol devices stops. This may cause external BACnet protocol devices to be flagged offline if they are not frequently sending data to their supervisory device.

If the free memory is critical, messages to be routed from one network to another through the controller are discarded. Additionally, information for routing to previously unknown network numbers are not saved. BACnet protocol messages received from the IP port are discarded. The IP port counter, **Discarded Frames** (under Eth IP Datalink, Diagnostic tab), displays the number of messages received and discarded by the IP port.

Protocol Engine Input Queue

The BACnet® Protocol Engine receives messages from external BACnet devices and holds them until the Protocol Engine can process them. If this queue becomes too large, the Protocol Engine is not capable of holding all of the messages in progress, causing some communications to fail.

If the Protocol Engine input queue is critical, BACnet protocol messages received from the IP port are discarded. The IP port counter, **Discarded Frames** (under the IP Datalink, Diagnostic tab), displays the number of discarded messages.

Protocol Engine Output Pending Queue

The BACnet® Protocol Engine has an output pending queue used to hold messages when slower communications links, such as MS/TP, are not able to keep up with the rate at which outgoing messages are generated. If this queue becomes too large, the time required to send a message becomes excessive, resulting in slow operation. When this slow operation occurs, applications begin to encounter errors and some devices may drop offline. Messages that are waiting are also counting down their APDU Timeout.

If the Protocol Engine output pending queue is in the trouble state or worse, reading the initial values at startup is delayed.

If the Protocol Engine output pending queue is critical, originated outgoing messages are discarded and the sending applications receive an error.



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